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CONTENTS

RUBBER CONFERENCE HELD ON NOV. 25TH, 1938.

FOREWORD

A Rubber Conference arranged by the Kalutara Planters' Association on behalf of the Planters' Association of Ceylon and with the co-operation of the Rubber Research Board, was held at Tebuwana Club on November 25th, 1938.

His Excellency the Governor of Ceylon, Sir Andrew Caldecott, K.C.M.G., C.B.E., opened the Conference at which the total attendance was 192, including representatives of all branches of the local rubber producing industry.

Opinion was unanimous that the conference was highly successful and that similar gatherings must be held periodically in the future. Among the valuable lessons learnt in regard to organisation were firstly, that advance copies of papers should be circulated to those attending the conference and, secondly, that the number of papers should be curtailed in order to allow ample time for discussion.

The proceedings of the conference are reproduced, herewith, as a permanent record. Unfortunately the discussions were not reported in full and the Press records have been amplified by inviting the chief speakers to provide a summary of their remarks.

Acknowledgment is made to the "Times of Ceylon" and the "Ceylon Daily News" for the use of their records and to the former paper for permission to reproduce the photograph of His Excellency declaring the Conference open.

OPENING OF CONFERENCE BY H. E. THE GOVERNOR OF CEYLON.

RUBBER CONFERENCE HELD ON NOVEMBER 25TH, 1938

H. E. THE GOVERNOR'S OPENING SPEECH

HIS EXCELLENCY said: "I do not propose to delay your opening by any long and learned speech — prepared by somebody else. The little I know of rubber planting I have learned from planters themselves, but I think you will agree that this does not disqualify me from hazarding a few introductory remarks.

When I first came out to the East 31 years ago what was expected of a Rubber planter was something quite different from what is expected of him today. Those were the days of giants, of huge tracts of virgin forest felled and burnt and planted. Malaria was often present; communications were poor; food was definitely bad; and drinks were hot. In fact a planter those days needed the strength of a horse and the constitution of a camel if he was to succeed. He also required a good knowledge of what was known as coolie-Tamil and bazaar-Malay, and he also needed personality and leadership to build up and retain his labour force. In those days a planter's job was a pioneer's job. Men sweated at it from dawn to dusk. There was little time for light reading, and none at all for serious reading.

It could not be said of planters that they were in the least scientific. Their methods and outlook were extensive and not intensive, and then as estates grew into bearing, as communication caught up with development, as conditions of life were ameliorated, there arrived a new era—the era of competitive rubber.

Ten years ago Mr. Ormsby-Gore (who recently became Lord Harlech), paid a visit to the East in the course of which he expressed the opinion that the Dutch plantations had outstripped British competition in the adjustment of outlook and of method that the new era necessitated. Hard things were said of Mr. Ormsby-Gore in up-country bars in Malaya, and hard things were wrtten of him in the Malayan Press, but whether as a result of criticism or not the subsequent years have witnessed a dynamically progressive attitude in Malayan planting circles in matters of agricultural theory, methods and experiments. I doubt indeed whether they have now very much to make up in their race with the Dutch. Can the same be said of Ceylon? The answer to that question is one that I must leave to you.

I must however, confess to some surprise at this being the first rubber conference ever held in the Island and at the little I have heard since I arrived in Ceylon of local planting on any extensive scale of proved clones. It may be, therefore, that there is a leeway to be made up, and, if so, that makes this Conference all the more necessary and important and my privilege in declaring this open is all the greater. This I now do, wishing it all success and congratulating the organisers very warmly."

MR. J. D. FARQUHARSON

(CHAIRMAN, KALUTARA PLANTERS' ASSOCIATION)

Mr. Farquharson said: "I am afraid no words of mine will convey fully how grateful we are to you for opening this conference, and for your very kind and interesting speech. We greatly appreciate the interest and encouragement you have shown us, both by coming all this distance to be with us, and by your words this morning. I thank you not only on behalf of those present, but for all those interested in the Rubber Industry of this Island, who have been unable to attend.

In welcoming you all here this morning, I wish to say how pleased I am to see so many present. I am also delighted to see so many who are not planters, and wish to thank them especially, for the interest they are thus showing in our work and our difficulties.

This conference is the first of its type for rubber that has been held in Ceylon, and you will appreciate that the Chairman's speech in this case may be long, but I shall try and be as brief as possible.

Our object today is to make this conference a success, and to do so, let us first study its name, "Conference," is to confer, that is to talk over, or discuss, and a conference without a discussion loses its meaning and value. May I ask you, one and all, to enter into discussions as much as possible; to impart information as well as to receive.

If each one of us leaves here today, feeling, either, that he has learnt something or contributed something, however small, this conference may be considered a success and an annual conference hereafter will be a major necessity.

I should like to touch for a few moments on today's agenda. Most of you are aware probably that the 14th annual conference was held in Penang in September and three lessons can be learnt from their report.

First that they are holding their 14th, second that their papers for discussions were published prior to the conference, this for the first time, and, third that a full day was spent on discussing the methods of planting up of jungle land.

I shall leave it to the Director of the Rubber Research Scheme to give us maybe some suggestions for future conferences.

I would like to give here, though, one more example of the necessity for co-operation. In regard to the purchase of high yielding material, we are playing at present, a child's great card game of 'Happy Families.' 'Dear A, can I have Mr. B.D.5, the Baker?' 'Sorry, not at home, please let me have Master TJ. 8, the Butcher's son!' 'Sorry,' and so on right around the Island, and which get us no forrader.

You will be interested to know that 26,025 acres have. and are being replanted since 1934 out of the Island Rubber, of 604,068 acres, approximately 1/23rd, and most of that has been opened, and our knowledge gained thereby, from bitter experience. My sincere hope is that conferences of this nature will help eliminate that bitterness.

We have not lost sight, however, of the fact that 500,000 odd acres still require attention, in order to keep the Industry alive and the papers on oidium, rubber manuring, and manufacture are on the agenda towards that purpose.

Before I sit down, I do wish to thank most sincerely all those who are so kindly reading papers today, and the others, too numerous to individualise, who have helped me so ably to

launch this conference, and for their sakes as well as my own, wish this conference every success.

I cannot close without special reference to the Rubber Research Scheme, and I wish to convey to the Director and his officers, our very sincere thanks, and our great admiration of them for all the good work they are doing, and for the tremendous help they are giving us, both in our work and at this conference.

His Excellency's keen eye will have noticed no doubt that the word 'Discussion' bristles through the agenda, implying correctly that there is a diversity of opinion in this hall, but I take this opportunity of informing His Excellency that one sincere and united feeling is in the heart of everyone present, our pleasure and gratitude to him, for being with us today, and for so kindly opening this conference."

MR. T. E. H. O'BRIEN
(DIRECTOR, RUBBER RESEARCH SCHEME)

Mr. O'Brien said: "I should like to congratulate the Chairman and members of the Kalutara Planters' Association and the Planters' Association of Ceylon on their initiative in sponsoring this conference. The large and very representative audience here today is an indication that their efforts have been appreciated. I had felt for some time the desirability of a Rubber Conference being held but so far as the Rubber Research Scheme is concerned, there was an initial difficulty in that we had no hall large enough for the purpose at Dartonfield. When Mr. Farquharson suggested a jointly organised conference I was only too glad to support the proposal, especially as the terms appeared to be such that he would do all the hard work while the Research officers would only be required to contribute a share of the papers.

The Ceylon Rubber Research Scheme dates back to 1913 and was re-constituted in its present form in 1930. We have, thus, been in existence, as representing the whole of the local rubber industry, for 8 years but the economic depression prevented any development being undertaken for several years. Dartonfield estate was purchased in 1933, a factory and chemical laboratory were built in 1934 and the main part of our building programme was completed in 1936. The first increase in scientific staff was made in 1934 when a chemist was recruited and we

have since appointed 3 additional officers on the agricultural side, thus bringing our staff up to the level which I recommended to the Research Board in a memorandum on the development of the Research Scheme prepared in 1932. We are now fully equipped and staffed within the limit of our resources and the industry can reasonably expect that very substantial progress will be made in dealing with local rubber research problems during the next few years.

It may not be out of place to mention that our development has been hampered by the uncertainty of the level of our income from year to year. Our main source of revenue is the cess of $\frac{1}{8}$ cent per lb. levied on rubber exported from Ceylon and we have been badly hit by the curtailment of exports under the Restriction Scheme. This year, for instance, our income will be approximately Rs. 50,000 less than was anticipated when the estimates of expenditure for the year were framed. It is only due to the conservative financial policy followed by the Board that we have been able to maintain our expenditure at the present level. In Malaya the cess is adjusted annually to meet the requirements of the Research Institute and both in Java and Sumatra I understand that the research organisations are assured of a stable income.

I should like to emphasise the importance of maintaining the continuity of research in various directions irrespective of temporary fluctuations in the prosperity of the industry. There is rather a temptation when prices are low to feel that the scientists should concentrate on problems relating to the increased consumption of rubber and then, when the market improves, to wish for their attention to be transferred to problems dealing with methods of increasing production. Any attempt to make frequent alterations in the orientation of research which is usually of a comparatively slow and long range nature, is bound to lead to disappointing results and wasted effort. The policy which has been followed by the Board is to maintain a balance between production and consumption research with, however, a definite bias on the production side. It is essential for an Institute such as ours to maintain a balanced staff so that sound advice can be given to the industry on any aspect of rubber production as the need arises, based either on work carried out locally, or on information gathered from other centres of work.

The Research Scheme maintains very cordial relations with the research organisations in other rubber producing countries and co-operation has been stimulated in the last few years by an exchange of visits between scientific officers. Prior to the initiation of our Smallholdings Department Mr. W. I. Pieris spent 2 months in Malaya under the auspices of the Rubber Research Institute studying the smallholdings work in progress in that country. Two years ago Mr. R. K. S. Murray accompanied by two Ceylon planters visited Malaya, Java and Sumatra for the special purpose of studying progress in the use of improved planting material and received the greatest assistance from the research organisations in all three countries. Since then we have been glad to have return visits from officers of each of the three sister organisations. The Malayan Institute has recently given a demonstration of helpful co-operation by lending us an expert budding Mandor for the purpose of checking the identity of clones on local estates. As many of you are aware that officer is at present engaged in a programme of visits to estates and is doing work of the greatest value to the country. I am sure you will join me in expressing our appreciation of the Institute's very practical assistance in this matter.

I hope the papers presented today both by the Research Scheme officers and others will prove interesting and stimulating and that this conference will be the forerunner of a very successful series."

THE BUDGRAFT AS A COMPOSITE PLANT

R. K. S. MURRAY

BOTANIST & MYCOLOGIST

(RUBBER RESEARCH SCHEME)

INTRODUCTION

ALMOST exactly a year ago I had the privilege of addressing the Kalutara Planters' Association in this building on the subject of "Planting Material." Concluding my remarks on the value of the budgraft as a form of planting material, I ventured to predict that although hitherto we had made our buddings on stocks which, at the best, were selected only on the basis of vigour, in the future we should have to pay increasing attention to the genetical control of the stock as well as of the scion. I suggested that the improvement of the budgraft would not be confined to the development of new clones, but that stock selection would also play a part. I am not able at this stage to say that my prediction has been completely vindicated — things do not happen so quickly in the realm of Rubber — but during the past year certain additional data have come to light which enable me to develop the theme rather more fully.

I have chosen the title of this paper with some care because it is on the conception of the composite nature of the budgrafted plant that I particularly wish to lay emphasis. In these days when budgrafting is a normal item of estate procedure we are apt, through familiarity, to take for granted what is really rather a marvellous biological phenomenon — the harmonious growth of the grafted tissues of two distinct living systems which have been brought into artificial union and compulsory interdependence. The graft consists of two parts: the stock, which normally provides only the root system, and the scion, which comprises the aerial parts of the plant, and the success of the budded tree

as an economic entity is entirely dependent on a congenial association between the two. There is perhaps, a greater tendency with Hevea than with other species to overlook the dual nature of the budded plant because the stock does not exert such a striking influence on the outward appearance of the scion as is the case with some crops, notably the apple. Moreover, the stock and scion are of the same species whereas in temperature fruit culture they are usually of different species or even genera, and in experimental work often exhibit marked incompatibility.

Although the stock effect does not catch the eye, recent experimental results suggest that this member may play a more distinctive rôle in the partnership than was formerly supposed, and my intention this morning is to summarise the available information on the mutual influence of stock and scion and discuss its practical significance.

THE COMPOUND LATEX SYSTEM

Before coming to economic considerations, however, I want to give you a rough picture of the laticiferous system of the compound budgrafted plant. I want you to visualise it as being a coherent complex, the respective systems of stock and scion preserving their own identity yet being able to influence one another by virtue of their connection at the point of union. I have no time to detail the evidence on which this picture is based, but you must be satisfied with the rather diffuse statement that physiological and anatomical studies above and below the union suggest that this is a true representation. They also show that there is a varying degree of co-operation between the two partners.

The inter-relationship between stock and scion can work both ways: it is possible for the scion to influence the stock and for the stock to influence the scion.

INFLUENCE OF SCION ON STOCK

I shall only make a passing reference to the influence of the scion on the stock because there are limitations both to the practical importance of such an effect and to the time at my disposal. Any influence which a high yielding crown might exert on the productive capacity of the stock is clearly only of interest if the graft is made at such a level that the tree can be tapped below the union. The present practice of budding just

above ground level could only be altered if there were sound reasons for supposing that it would be more productive to tap the stock below the union than the scion above it. The balance of evidence is entirely against this supposition, though there is reason to suppose that with some clones, at any rate, the number of latex vessel rows and the yield are somewhat greater immediately below the union than they would have been at the same height had the tree not been budded with a high yielding crown.

In actual fact the evidence on this point is somewhat contradictory. In an experiment on the A.V.R.O.S. Station in Sumatra it was found that the yield of stocks budded high with Clones 49 and 50 was no higher than that of corresponding unbudded seedlings despite the fact that these are both moderately high yielding clones, and a more recent experiment in Malaya with four well known clones is giving similar indications. On the other hand, in an experiment at the Proefstation West Java the yield below the union in the case of certain clones was as much as 60 per cent higher than that of the control unbudded seedlings. The easiest way of explaining the discrepancy is to assume that only certain clones have an appreciable effect on the yield of the stock, but the technique of these experiments must also rest under some suspicion since no satisfactory method of propagating uniform stocks on a large scale has yet been devised.

I think we may safely conclude that the influence of the scion on the stock is a matter of relatively little practical importance, and I will now turn to the part that the stock plays in controlling the development and yield of the scion.

INFLUENCE OF STOCK ON SCION

The attributes of a stock that may be expected to exert an influence on the yield of the scion may be considered under three headings:—

(1) Vigour of growth.
(2) Potential productive capacity.
(3) Efficiency of the fusion between the latex vessels, and also other bast elements, of the stock and the scion. This, of course, will be a function of the scion as well as the stock.

Vigour of Growth.—The probability that the development on a strong growing stock will be more rapid than on a weak stock has been recognised from the early days of budding, and

has been put into practice in the general custom of planting in the nursery or the field a larger number of seedlings than will actually be required as stocks, and budding only the largest of them. Although such procedure has been dictated more by common-sense than anything else, there is experimental evidence to show that the vigour of the stock is of importance. I saw one of the most convincing of these experiments when I was in Java two years ago. Since the results have not yet been published I cannot give you full details, but I think I may outline the general conclusions.

As some of you are doubtless aware it is possible by bisecting the young stem with a sharp knife to raise twin seedlings from a single seed. The members of each pair, as would be expected from their identical genotype, show marked similarity to one another and to all intents and purposes may be considered identical. In this particular experiment rather more than 100 pairs of twins were raised, and at a suitable stage one member of each pair was budded with a standard clone. The unbudded seedlings show the usual degree of variation in growth which is to be expected from a mixed population, and wherever the unbudded member of a pair is vigorous the scion budded on to the twin is also vigorous, and *vice-versâ*.

There is further experimental evidence to support the contention that strong stocks produce strong scions though the effect is not always as marked as might be expected. The problem is how to give practical effect to this conclusion.

An investigation carried out in Java showed that the early growth of seedlings planted in a nursery is not an altogether reliable indication of the subsequent vigour of the stump when transplanted to the field. The seedlings which show the slowest growth in the first month or two are suppressed by the quicker development of their neighbours and do not have a fair chance of revealing their potential vigour. This disability would be overcome by wider planting in the nursery, but the necessary extra space is not always available. The ideal solution would be to plant only stocks from parents known to give vigorous progeny, such as buddings of Clone A.V.R.O.S. 163, but at present we are limited both by our knowledge of the performance of clonal families and by the scarcity of supplies of such seed.

It should not be inferred from my remarks that the present practice of selecting nursery stocks on the basis of vigour is

entirely ineffective and should be discarded. Quite apart from the question of future growth we have always found that the best budding results are obtained on the bigger stocks.

Before leaving this subject of stock vigour I must refer briefly to an experiment in progress on the A.V.R.O.S. Station in Sumatra, of which the early results have just been published. Buddings of Clones 49, 50 and 256 were made in 1931 on stock raised from ordinary unselected *Hevea brasiliensis* seed and from seed resulting from the cross fertilisation of *H. brasiliensis* and the related species *H. Spruceana*. In 1938 the buddings on the hybrid stocks were 10-17 per cent larger than those on the *H. brasiliensis* stocks. At first the yields on the hybrid stocks were lower, but in 1937, the third year of tapping, the yields were 14-35 per cent higher. I have mentioned these results to show that the future possibilities of stock selection are not necessarily confined to our species *Hevea brasiliensis*.

Potential Productive Capacity.—I now turn to the second property of the stock which might be expected to influence the yield of the scion, namely its productive capacity. Until comparatively recently it was thought that the potential yield of the stock had no effect on that of the scion, but the two experiments I am about to describe have caused us to modify this opinion.

The first experiment is one conducted on the A.V.R.O.S. Station. Clones A.V.R.O.S. 49 & 50 were budded on to stocks raised from illegitimate clonal seed of a number of clones including 49 & 50 themselves, A.V.R.O.S. 163 which is known to give high yielding seedlings, and A.V.R.O.S. 180 which is known as a very poor yielder. Representative groups of the seedlings were also left unbudded so that it was possible to study the yield of one and the same clone on different stocks in relation to the yields of the stocks themselves.

I do not want to confuse you with a lot of figures and will therefore content myself with the main conclusions. With both Clones 49 and 50 the best yield was obtained on stocks of 163, the unbudded seedlings of which were, with one exception, the highest yielding. Considering the yield figures for the first 6 months of 1936, in the case of 49 the advantage of 163 over 49 stocks was 14 per cent and in the case of 50 the advantage of 163 over 50 stocks was 23 per cent. Comparing the yield on the high yielding 163 stocks with that on the low yielding 180 stocks, there was an advantage of 18 per cent in the case of A.V.R.O.S.

49 and 32 per cent in the case of A.V.R.O.S. 50. It would appear that Clone 50 is more susceptible to stock influence than 49.

These differences, which are large enough to be of considerable practical importance, are almost certainly not wholly due to the potential productive capacity of the stocks. The seedlings of Clone 163, as well as developing a high average yield. are also very vigorous in growth, and this is reflected in the slightly greater girth of the buddings on these stocks than on their own seedlings. Moreover, one of the clonal families used as stocks was A.V.R.O.S. 33, and although the yield of these seedlings is slightly higher than that of 163 seedlings, the buddings on these stocks are less productive.

It would seem that the superiority of the 163 stocks is due partly to their vigorous growth, partly to their potential high yield and partly to some other factor or factors connected with the fusion of the grafted tissues.

The second experiment that I want to describe is one that was initiated at the Experiment Station, Nivitigalakele, in 1927, but of which we have only recently been able to work out the full results.

All experimental work on stock-scion relationships suffers from the difficulty that no satisfactory means of raising uniform stocks on a large scale has yet been devised. I have mentioned an experiment in Java in which stocks were developed in duplicate by the method of twinning; in the experiment I am about to describe a similar effect was achieved by vegetatively reproducing the stock by the process known as marcotting. A number of stocks were budded in the ordinary way, but when the bud had taken the stock, instead of being cut off and thrown away, was marcotted and subsequently planted. In this way a number of pairs was established, one member of each of which consists of the marcot, representing the stock growing on its own (adventitious) root system, and the other the scion growing on the stock root system. The marcot is thus genetically identical with the stock on which the scion is growing, and may be considered to represent what the stock would have been had it not been budded. For each pair we thus have a measure of the performance of the stock and of the composite plant. Any influence which the stock may exert on the scion would be reflected in a correlation between the members of a pair. The

statistic employed to measure this correlation is called the "coefficient of correlation," and I must digress for a moment to explain the meaning of this term.

Consider for a moment two variables such as the height and weight of a population of children. It is clear that, in general, the taller children will also be the heavier. It is equally clear that this is not always the case because there are some children who are tall and thin and others who are short and fat. There is what we call a partial positive correlation between these two variables. The coefficient by which this relationship is expressed varies from +1 for a perfect positive correlation to −1 for a perfect negative correlation. A figure higher than 0·5 is regarded as a high correlation.

Returning to our pairs of buddings and marcots, the correlation coefficient for yield was calculated for 31 pairs. The yield was measured in relation to the length of the tapping cut in order as far as possible to compensate for the ineluctable variation due to position. The following values were obtained in the years 1935-37 for the stated heights of the tapping cut on the budded trees:—

Year		Height of cut on buddings at end of tapping year	Correlation Coeff. (Yield per inch of cut)
1935	...	15½ ins.	+.2004
1936	...	10 ,,	+.5059
1937	...	4½ ,,	+.6473

The figure for 1935, when the height of the tapping cut on the buddings was from 21 to 15½ ins., is not statistically significant, but for 1936 and 1937 the correlation is highly significant. This indicates that as the tapping cut approaches the union the yield becomes more and more controlled by the potential production of the stock. This is to be expected since when the cut is close to the union the latex must be drawn from a zone which includes the junction and a considerable portion of the stock. The figures suggest that it is only when the tapping cut is within about 15 inches of the union that the stock effect becomes important.

We have so far concluded that the vigour of growth and the potential yield of the stock influence to some extent the corresponding characters of the scion growing upon it. There remains the far more complex aspect of the subject which I have referred to as the efficiency of the fusion between the latex vessels and other bast elements of the two partners, and which may be covered by the term "compatibility."

Fusion of Latex Vessels and Other Bast Elements.—I hav'nt the time to do much more than indicate the possibilities of this very fascinating study. The existence of varying compatibility between stock and scion has been demonstrated in Java by anatomical investigations in the locality of the union. It has been found that the degree of communication between the latex vessels varies with different stocks, and the practical importance of this is clear. If the communication is inefficient not only will the yield be affected when the tapping cut approaches the union but the tree is likely to develop Brown Bast. It is a matter of common experience further East that the incidence of this disease increases as the cut approaches the union.

The stock and scion may also exhibit varying degrees of co-operation as regards the ordinary conducting elements of the cortex. For instance, in the ordinary way the situation as regards food reserves is much the same with both partners, but in individual cases where the buddings are wilting the scion may be found to be entirely devoid of starch while the stock at the point of union is loaded with it.

On *a priori* grounds one would imagine that the maximum compatibility would be manifested when there was a close family affinity between the two series of tissues, but in actual fact it is doubtful whether this is so. In an experiment on the Department of Agriculture Experiment Station at Peradeniya 10 clones were budded (a) on to ordinary mixed stocks, and (b) on to stocks derived from illegitimate seed from the respective mother trees. The success of the budding operation and early growth showed no advantage in favour of the grafts made on related stocks, and this is confirmed by recent measurements made at an age of 7 years. It would thus appear that as far as growth is concerned there is no advantage in budding on seedlings of the same clone, though it is possible that a beneficial effect may be noted when the trees are tapped in the vicinity of the union.

The experiment which I have already described, in which Clones A.V.R.O.S. 49 and 50 budded on to illegitimate seedlings of Clone 163 have given higher yields than when budded on to their own seedlings, points the same way. It is possible that, other things being equal, it would be better for the stock and scion to have a common origin, but in practice other things never are equal and it would seem that any advantage due to affinity of tissues is usually outweighed by other factors.

PRACTICAL CONCLUSIONS

Now what does all this amount to and how are we to turn our findings to practical account? The investigation of stock-scion relationship is still in its infancy and at present we are merely confronted with a number of independent facts, some of them contradictory. I think we are justified, however, in drawing the following conclusions:—

(1). In the case of some clones the scion may exert an influence on the yield of the stock, but this is of limited practical importance.

(2). There is undoubted evidence that the stock can influence the rate of development and the yield of the scion growing upon it.

(3). The effect may be of the order of at least 30 per cent, which is a matter of considerable economic importance, and becomes more marked as the tapping cut approaches the union.

(4). It is probable that some clones are more susceptible to stock influence than others.

(5). The properties of the stock to which this influence may be attributed are:—

(a) Vigorous growth.

(b) High productive capacity.

(c) Compatibility with the cortical tissues of the scion.

Our ideal stock, therefore, should be one which grows vigorously, which would develop a high yield if it were not budded, and which has been shown to co-operate well with the particular clone to be used.

We are a very long way from being able to produce this ideal stock, and it may reasonably be argued that if we could

grow seedlings which we knew to be high yielding there would be no need to bud them. This is a matter for future consideration; at present, as most of you know, the variability and uncertainty of any form of seedling material commercially available is such that we consider budgrafting with proved clones to be necessary. We are beginning, however, to learn something of the seedling progeny of the well known clones and that certain families, in particular, give high average yields.

Our present advice for the selection of stocks is as follows:—

If seed collected from the buddings of proved high yielding clones is available on the estate or can be purchased at a reasonable price, lay down nurseries of such seed keeping the families separate. Give these plants the same cultivation treatment as usual, and use as stocks any plants which are up to the criterion of growth that would be applied for ordinary seedlings. It will be found that certain families show much more vigorous growth than others. For example, in a collection in Malaya seedlings of B.D. 10 at a year old were more than 50 per cent bigger than seedlings of B.D. 5. Clones which are likely to give valuable stocks include A.V.R.O.S. 163, Tjirandji 1 and B.D. 10, and we shall be able to add to this list as further knowledge is gained.

If clonal seed is not readily obtainable use seed collected from high yielding trees or high yielding areas. Although I consider that the fact of stock influence has now been clearly established, we do not yet know enough about the reaction of any one clone to seedlings from any one source to justify the expenditure of large sums of money on buying seed at a high price.

In conclusion, I wish to allay any apprehension that my remarks may have caused regarding the fate of buddings made hitherto on unselected stocks. All our evidence of the high yield of the approved clones has been derived from grafts made on such stocks. It is not, therefore, that such buddings will prove unsatisfactory but that with the use of improved stock even higher yields will be obtainable. The object of my address has been to indicate that we are at the beginning of an era in which the use of seedlings of unknown parentage as stocks will not be considered sufficient for the scion to develop its full productive capacity.

DISCUSSION

Mr. V. Roe asked what variation was found in the yield of individual trees of a clone. Mr. Murray replied that, expressed statistically as the coefficient of variability, the figure was about 20-25 per cent. The corresponding figure for ordinary unselected seedlings was about 60 per cent.

Mr. E. T. Fernando asked whether Mr. Murray was in a position to recommend a stock that would have specially good anchorage.

Mr. Murray: "No, but the Rubber Research Institute of Malaya have found that clonal seedling families develop characteristic root systems and they are investigating the use of the more divergent types as stocks. Provided the plant is put into a satisfactory hole anchorage is not, in our experience, a common point of weakness."

Mr. A. H. Healey suggested the possibility of thinning a field selectively down to 20 per cent of the original stand and then using the field as a "seed nursery" for stocks for replanting schemes.

Mr. Muray considered the suggestion a very useful one.

Mr. W. R. Thomson quoted an instance of such selection having been done further east on an isolated area and said that the seedlings from this area gave a yield comparable with that of high grade clonal seed.

Mr. Whitelaw questioned the value of illegitimate clonal seedlings as stocks in view of the uncertainty regarding the yield of such material.

Mr. Murray replied that although it was true that the yield of most clonal seedling families was rather an uncertain quantity and would usually be lower than that of budgrafts of the best clones, yet such material would, in general, be superior to seed collected in an ordinary plantation. He would, however, only recommend the use of clonal seedlings as stocks if due regard were had to vigour of growth.

THE DIFFICULTIES OF REPLANTING IN THE DRY ZONES

M. ATKINSON

(KEPITIGALLA ESTATE)

SINCE the early days of Rubber in Ceylon it has generally been accepted that Kalutara, with its rainfall of 150 inches a year, and the Kelani Valley, and the Ratnapura districts, with a similar or greater rainfall, are the best districts for Rubber, and that other zones, with a rainfall of 80 inches are too dry for this product.

But in the light of our present day knowledge this is becoming a somewhat questionable assumption.

Up till about 12 years ago the system of clean weeding and 'herring bone' drainage was adopted on practically every Rubber estate in Ceylon.

Under such a system, who can say that Kalutara did not lose 70 inches of its rainfall, leaving an absorption of 80 inches.

And under modern methods of replanting we can say that in the Dry Zones practically every drop of our 80 inches of rainfall is trapped and absorbed into the land, and we owe it to Kalutara that a system was introduced which made this possible.

The Dry Zones still have the disadvantage of a poor distribution of rainfall, and periodic droughts and partial failures of monsoons bring about difficulties in the early stages of replanting that are not experienced elsewhere.

It may scarcely seem within the province of this paper to discuss such things as weeding problems, but some areas in the Dry Zones are notorious for weed growth, and as the effective control of weeds and grasses bears important relation to the ultimate success of a clearing it may not be out of place to refer to this subject.

Where a stand of old Rubber to be replanted has for some period carried a heavy cover of leguminous ground creepers a weeding problem is not likely to arise.

But if the doubtful policy of selective weeding has been in vogue, the land will have become impregnated with every conceivable kind of weed and grass seed, and once the old Rubber is felled and the land exposed to the light of day, weed growth can become a bewildering problem.

I have tried various methods of dealing with such problems, but the system I favour now is as follows:—

To fell, clear and burn the old stand of Rubber as one complete operation.

A start is then made at the top of a field and a small section of not more than $1\frac{1}{2}$ to 2 acres is lined on the contour system.

This is holed, and clean weeded. All weeds are collected and piled into stacks 8 feet long, 8 feet wide and 3 feet high for compost.

The amount of compost will vary and may be anything from 2 to 5 tons per acre.

After three months, this becomes available as a dark rich loam and may be applied to the plants at any convenient time.

Following immediately on the clean weeding, the holes are filled with surrounding top soil and the entire area is trenched.

Ground cover seed is then broadcast along the bunds of new earth at the rate of about 10 lbs. per acre.

From that date on, monthly weeding rounds are essential and although expenditure may be heavy during the first year it will most surely be the most economical in the long run.

This general system has perhaps a further advantage in that holing, weeding, filling holes and trenching are carried out almost as one operation and a large gang can be employed in a comparatively small area which makes for more effective supervision.

With the first section thus completed, we move down the hill leaving behind us a complete work, ready for planting at the first available opportunity.

NURSERIES

It is generally accepted that seedlings are suitable for budding when they attain a diameter of 1 inch at the collar and this should occur about 9 to 10 months after planting.

But in the Dry Zones one cannot always be certain that nursery plants will become buddable in 10 months, and we have had such an example this year.

The South West monsoon was a failure and the average rainfall registered in the Matale and Kurnegala districts between the 1st May and 15th September, a period of $4\frac{1}{2}$ months, was 8 inches.

At no time during that period did we get as much as 2 ins. in any one fortnight, or as much as 1 inch in any one day. It came in the form of light showers, ·10 to ·20 of an inch, rain that never penetrated the soil at all, and which was almost completely nullified by the strong drying winds we sometimes get in those districts.

Nurseries laid down last September were completely dormant during that period, as was the growth of young plants in the field.

In the clearings, at a time when we should be making good progress, holing and trenching was seriously delayed and work was almost at a standstill.

Altogether it was a depressing period of all round inactivity.

But the Rubber plant is very tenacious of life, and it is astonishing how, once suitable rains set in, the nurseries and the plants in the field seem to leap to life and put on fresh, vigorous new tops.

In 12 months some of the plants have reached a buddable size, but it is safe to say they will have to be left till next April before budding can be undertaken in a general way.

I have found it a great advantage to litter a nursery with paddy straw 3 inches deep about a month after planting. This is applied at the rate of 4 lbs. per square yard, or 8 tons per acre.

It immediately checks weed growth and keeps the soil cool and moist. During dry spells the soil never becomes baked, and if paddy straw is conveniently available I would always make full use of it.

In passing, it might be as well to try and ascertain which type of manure is most suited for a local area. In colloboration with my Visiting Agent and Mr. Murray a manuring experiment was laid down last April, and without going into detail, we

have discovered beyond all question of doubt that a manure which forms the basis of the experiment gives infinitely better results than a manure we have been using generally, and at a smaller cost.

BUDGRAFTING AND PLANTING

It may seem elementary to state that a budgrafting programme cannot be governed by dates, and that a plant will only take a bud successfully when it is in a fresh and vigorous state of growth, and not when it is dormant as happens in dry weather.

Transplanting, and the immediate after-care of plants is perhaps the most vital of all operations governing a replanting programme in the Dry Zones.

I have tried various methods:—

(1). Ring barking in the nursery 10 days before planting; and this has given excellent results, though I would be afraid to adopt this policy on a large scale as it enforces transplanting into the field 10 days later irrespective of what the weather conditions may be.

(2). Planting out budded stumps cut across 18 inches above the bud and allowing the natural shoots to develop until such time as the roots have become thoroughly established.

(3). Planting out budded stumps from estates in other areas, some cut across at 18 inches and some at 6 inches.

(4). Planting out stumps from my own nurseries, cut across at 4 inches above the bud — and if for no other reason than that the smaller stump can be effectively shaded, and that any failures can be resupplied at a comparatively early date, this is the system I favour most.

The moment a budgrafted plant is pulled out of the nursery it begins to die; and the sooner a Superintendent gets this firmly impressed on his mind the sooner will he take all due precautions to deal with the position.

The standardised system on which I now work is to pull the plants with the utmost care so as to do the least possible damage to the root system.

The stems are then sawn off 4 inches above the bud patch and the sawn end dipped in melted wax.

The roots are then dipped into a barrel of fairly thick liquid cow dung and the stumps piled into convenient loads and covered with leaves.

They are taken to the field the same afternoon, planted and completely shaded.

If the soil is not saturated, watering is done the next day, and on following days as far as conditions allow.

Nothing can be more disheartening than to see failures and vacancies where there should be successfully budded plants.

And nothing can be more pleasing to a Superintendent than to see his fields coming away evenly and well, and if he can get 95 successes out of every 100 planted, anything he may have spent in the way of extra shading and watering will have been well repaid.

BUDDING IN THE NURSERY OR IN THE FIELD

In view of what may seem somewhat elaborate precautions necessary in transplanting in the Dry Zones one's thoughts not unnaturally turn to the alternative of budding in the field.

If four good seedlings to each hole are available for budding, say a year after planting, there should be no great difficulty in budding two plants to each hole in the first round, and, where necessary, the other two in the second round to complete a successful operation.

My observations are that buds from such plants come away very strongly and maintain their development, and I cannot but think that by the time they are seven years old they will be as good as transplanted stumps planted a year previously.

The same care is needed in dealing with germinated seeds and basket plants. Germinated seeds, after they have been transferred to baskets can be very severely damaged by wind when they are about a week or two weeks old and I have found it best to store them in long trenches 3 feet wide and 3 feet deep until they are ready to be planted in the field. And after planting, protection baskets costing 2 to 3 cts.

each are absolutely essential if every single plant is to be protected from damage by hare — or by careless weeders.

Any plant which has to be replaced means that when it reaches the stage of having to develop its crown it will be crowded out by the more rapid development of the neighbouring trees.

DOES REPLANTING IN THE DRY ZONES PAY?

And now, what of the ultimate results of replanting in the Dry Zones?

I have long held the view that the comparatively poor yields, and poor bark renewal in old Rubber have been due, not entirely to the fact that we clean weeded and allowed the land to become hard and baked during drought, not entirely to lack of rainfall — though we lost our due proportion with our 'herring bone' drains, but to a lack of humidity round the tapping panel and over exposure to the sun and the strong drying winds we experience in the zones I refer to.

But in the replanted areas, tapping statistics have revealed the illuminating fact that yields from certain clones are much about the same as from identical clones in the wetter districts.

I recently had occasion to inspect estates in the Kurunegala district and saw nine different clones in tapping.

Their general appearance, and the foliage, was magnificent; indeed, this applies to clearings of all ages in the Kurunegala and Matale districts.

Yields, I have referred to. The bark renewal was astonishing. Out of nine clones inspected two showed a bark renewal of 7 mm. six months after tapping, three showed a renewal of 4 mm., 6 mm., two showed a renewal of 5 mm. and two a renewal of 4 mm.

By the process of elimination, therefore, we are now able to decide which clones are most suited for these districts, and further investigation will, doubtless, prove that the Dry Zones will not be limited to a small selection.

SUMMARY

To sum up the position, therefore, whatever difficulties we may have to face and overcome in the early stages of replanting, with the construction of earthworks designed to tap and absorb

practically every drop to our rainfall, by the establishment of leguminous ground creepers which play their important part in soil improvement, and by the creation of a greater degree of humidity round the tapping panel which will automatically follow from the heavier canopy of budgrafted foliage, there is every reason to believe that the so-called Dry Zones will produce replanted areas equally as good as those to be found elsewhere in Ceylon.

DISCUSSION

Mr. G. B. Foote said he was interested in the scheme for littering a nursery with paddy straw to suppress weed growth and keep the soil moist but enquired whether this treatment gave rise to trouble with cockchafer grubs.

Mr. Atkinson replied that he had not experienced any such trouble. The nursery referred to was now about 14 months old and he did not think there was a single vacancy in it.

Mr. E. W. Whitelaw enquired what manures had been used in the experiment referred to.

Mr. Atkinson replied that sulphate of ammonia, concentrated superphosphate and muriate of potash had been used. Applied singly nitrogen gave the best results, then phosphoric acid. Potash did very little good.

A combination of all three, however, gave better results than a proprietary organic fertiliser which had been in general use and the cost was less.

SOME ASPECTS OF MANURING RUBBER.

H. W. R. BERTRAND
(GOVINNA ESTATE)

IN a short paper it is possible to deal only with a few of the interesting aspects of this question and with but little of the work which has led up to present practice. I propose offering a few remarks on practices and manurial problems which have occurred to me.

OLD RUBBER

We have, for some 12 years now got away from the mixture containing a little of everything in the cruet stand, which entailed an enormous initial and transport cost per unit, and which, having a high organic content, had to be forked in, with consequent soil losses and root damage.

This contains three statements worth considering.

Transport.—Let me briefly illustrate this by a *reductio ad absurdum* argument. Consider a "mix" containing ground nut cake, 7 per cent nitrogen and one containing urea with 47 per cent nitrogen. In the first case, for every 7 tons of nitrogen we pay for the transport of 93 tons of non-nitrogenous matter which can be far more economically grown on the estate. On the other hand, in 100 tons of urea we get 47 tons of available nitrogen and pay for the transport of only 53 tons of non-essential matter. Put in another way 15 tons of urea contain more available nitrogen than 100 tons of cake.

Again take a mixture containing fish, the fish in which costs say Rs. 110/- per ton landed in the field. Every ton used would give 90 lbs. of nitrogen and 90 lbs. of phosphoric, whereas a ton of Nicifos No. 2 costing Rs. 198/- landed in the field would give 393 lbs. of each. For the above Rs. 110/- one would get 217 lbs. each of nitrogen and phosphoric as Nicifos. These figures

are based on a cost of transport of only Rs. 10/- per ton *landed in the field*. For many steep and distant estates it is often more than double, in which case the discrepancy is much greater.

In a paper read at a Conference in 1927 I was told that I had overlooked the micro-fauna and flora. This was not so. I contended then and I still maintain that we should apply our manurial ingredients in the cheapest inorganic form and *grow* our organics. In the course of the last 11 years I have seen no reason whatever to justify paying some two and a half times as much for a source of nitrogen, or conversely, applying for the same cost, an inadequate amount. It is not denied that organic matter plays an important part in the nitrogen cycle of the living soil, but such considerations as the above have led to the abandonment of organics in Rubber. Some advocate the addition of cake or blood to a mixture of salts purely as a conditioner. I have not found this necessary, though there is a definite need for a suitable cheap diluent and damper to reduce the dust and causticity of cynamide and slag mixtures.

FORKING IN MANURE

Whatever the merits or not of organics versus inorganics, one thing is certain, that organics *must* be forked in, whereas there is a case for simply broadcasting inorganics.

Before deciding, therefore, whether or not to fork, let us consider some of the *pros* and *cons*.

Working the soil is the oldest agricultural practice, its advantages, in fact, are so well known, and with many crops so essential, that its disadvantages in mature Rubber are often overlooked.

Let us first see how forking affects the *cost* of manuring. Most old Rubber suffered severely in the past from clean weeding, erosion, and inadequate manuring. In the majority of cases this has resulted in a deficiency of humus and nitrogen. It is now generally admitted that in such cases heavy doses of nitrogen are necessary, and that it is only the cost which limits the amount which can usefully be applied. Those who have closely compared the usual effect on foliage of a dose of say 64 lbs. of nitrogen per acre, as against one of 80 lbs. cannot fail to have been impressed with the striking difference in favour of the bigger dose. Now, reasonably good envelope forking costs about Rs. 5/- per acre. If this amount were spent on sulphate of ammonia, simply broadcast, a further 16 lbs. of nitrogen could be applied, bringing the 64 up to 80 lbs.

It may be argued that a 64 lbs. dose forked in is better than 80 lbs. broadcast. I can only tell you that in my experience of both, over many years, it is not. But if any one doubts this it will be better worth while to try it out than argue about it.

DOES FORKING CAUSE OR LESSEN SOIL EROSION?

This is another point too important for us to be biassed by text book or Tea notions. We have here a *special* case, special conditions. It is often stated that the deeper the forking the less the wash. Applied to old Rubber, this statement means that we can fork deep enough to make the soil absorb all the rainfall. If we cannot, then, when a run-off occurs beyond the soil's absorbent capacity, one would expect the wash to be greater.

Some years ago this seemed to me of sufficient importance to have some more definite knowledge than a belief. A uniform slope with average drains was chosen and some 16 acres had new silt-pits cut at even distances in the drains. It was divided up into four blocks.

A was left unforked.

B was lightly mamoty forked.

C was deep envelope forked.

D was very deeply forked with big pickaxes.

After the monsoon in the unforked area the pits were still empty. In the lightly forked area the pits were about quarter full; in the envelope forked area the pits were three-quarters full; and in the deep pickaxed area they were overflowing and full of white sand, *i.e.*, all the humus and colloids had gone.

Again, during the last 12 years I have not stuck a fork into Govinna, except in two 20-acre fields to encourage a ground cover. My assistant — Mr. Minor, engaged after this, and ignorant of the field's past history, asked me why the silt-pits in these fields were full whereas in the rest of the estate they were empty!

Even careful envelope forking causes much root damage, as evidenced by the noise of breaking roots. Observation shows that it takes several weeks for severed roots to resume their function. To break up a root system and immediately apply a soluble or rapidly convertible manure, particularly nitrogen, seems illogical.

If blown down trees in an old well forked area are examined it will often be seen that the big anchoring laterals end only a few feet from the tree; from there outwards they divide, at a formerly broken point into comparatively small roots, thus greatly weakening the hold.

Root damage and diseases are, of course, related. Though there would not appear to be much evidence that this is serious, observant planters have told me that they associate pod and leaf disease with forking. Possibly too drastic spring forking, like root pruning, causes abnormally early and heavy pod setting, thus favouring *Phytophthora* in a bad monsoon.

There is, presumably, with a deciduous tree and two monsoons, *a best time to manure*, but a great disadvantage of forking is the time and labour it takes. Whereas broadcasting can be done over a very large acreage in a short time, forking often takes months.

Breaking up the spring roots and running the application close, or into, the monsoons must surely be wrong.

These, then, are some of the reasons why I consider forking manure into old Rubber unsound.

BROADCASTING

One of the disadvantages attributed to this is that it may cause surface rooting. Careful examination of forked and unforked areas shows that there is actually more rootlet exposure in the former than in the latter.

There used, also, to be much talk of the manure going down the drain. We are indebted to Mr. P. A. Keiller for disproving this by a valuable experiment. If the ground is fairly dry it usually takes about $\frac{3}{4}$ inch of rain before any run-off occurs. That amount, therefore, together with any solubles, is absorbed by the soil. If rain continues it will merely run off the surface *above* the salts which are already underground.

Therefore, there would appear to be a strong case for only broadcasting soluble manure in old Rubber.

TIME OF APPLICATION

Views on this important point differ considerably and little or no statistical work has been done on it, but there must surely be an optimum period.

Even nowadays one does occasionally hear of forking and application being done simultaneously through either or both monsoons. Fortunately for shareholders this is rare. There are, however, three periods during the year favoured by many.

(a) Feb.-Mar., (b) August, (c) November-December.

There is much to be said for the first period. Rubber is a deciduous tree; it would therefore seem sound to apply the manure at the earliest period in the leaf's short annual life at which it can be fully utilised. This, also, is soon enough for it to be completely taken up before the heavy May-June rains. Moreover, backward trees winter and refoliate first. They, therefore, at this time, get first call on the manure, thus helping to even up the stand. Further, it coincides with the resting period, thus giving employment to labourers. It has the disadvantage that a company is committed to heavy expenditure at the beginning of the year, but this could be obviated if there were a special reserve for cultivation.

For the August Period—there is not this disadvantage and there is also the following in its favour. In normal years the spring period is one of considerable soil aeration and nitrification, and, owing to "wintering," nitrogen is temporarily less drawn on. In some districts, particularly in Travancore, the effect of this accumulated nitrogen is most marked. Immediately prior to the monsoon, there, even old trees carry magnificent dark foliage and young tops.

During much of the monsoon that follows the air is saturated. In a saturated atmosphere there can be little or no evaporation from the leaves and therefore minimum intake of solutes.

Meanwhile the anærobic or soaked condition of the soil is not favourable for nitrification, also any free nitrates are most liable to be leached away. The result is that the pre-monsoon foliage which looked so grand begins to stale, though it still has before it some six months of what should be its most useful photo-synthetic period.

There is much, therefore, to be said for a post-monsoon application, and I am inclined to think that, lacking fuller knowledge, companies might well do some of both.

As regards the November-December period I can think of no sound argument in its favour for the south-west zone. If the roots of backward trees have begun to pack up, they, which

most need it, will get little of the manure. The vigorous late winterers will collar most and their wintering is often deferred into the bad Oidium season.

To sum up, there would appear to be a strong case for *broadcasting inorganics*, in old Rubber, either in early spring or just after the South-West monsoon.

MANURIAL INGREDIENTS

In the case of mature Rubber, particularly that which in past years suffered from bad soil management and lack of or inefficient manuring, I have no doubt that the first need is nitrogen in large doses of 70 to 80 lbs. and it is surprising what an enormous improvement this effects on old, tired, hard-barked trees, particularly if given two years in succession.

The visible effect is so marked that there is some danger of carrying on too long without a change in the vehicle of nitrogen. It would seem advisable to treat some fields in rotation every year with calcium cyanamide, or cyanamide and nitrate of soda, instead of continued biennial applications of sulphate of ammonia. Apart from its partially corrective action against increased acidity, cyanamide contains calcium, an element deficient in wet zone soils, but none the less necessary in small quantities for the metabolism of the tree and for the healthy growth of leguminous covers and soil bacteria.

Unfortunately cyanamide is horrible stuff to handle. Labourers should on no account be given continuous work applying it.

The continued application of nitrogen only, once that deficiency has been made good, would seem unsound. Heavy applications of nitrogen stimulate growth, which increases the drain on the other elements, already lacking in our soils. But it is not economically possible, in the first year or two of manuring starved Rubber, to apply an adequate dose of nitrogen, costing say Rs. 25, and also phosphoric and potash costing say a further Rs. 10. It should also be remembered that there is a lower limit to the effective dose. If, therefore, it is considered desirable to add phosphoric and potash it would seem sounder rather to add these to fields in rotation than to give ineffective doses to a larger area. The best results I have ever seen in mature Rubber were got with equal applications of all three elements, but the cost was too high. If one has to cut

out one or more of the three it seems certain that the first to be retained is nitrogen, the second phosphoric, and the last potash. On the other hand, when dealing with large neglected acreages, a reduced dose and a short purse, would it be better to spend say Rs. 7 on phosphoric and nothing on potash, or to make do with say Rs. 4-50 on phosphoric and Rs. 2-50 on potash?

After fuller results have been got on Dartonfield we may know more about it, but even those results are only strictly applicable to their particular conditions. The manuring of a boulder strewn soil comparatively rich in humus, and that of a stoneless scraped laterite, although the subsoils may be similar, are two totally different problems, yet, although very large sums may be involved, how often does one see any attempt at such discrimination?

There is, to my mind, too great a tendency to generalize; to forget that whatever be the results of say, an experiment in Malaya, useful as these are, if we understand the exact conditions, that agriculture is an art and not, so far, an exact science, the few findings of which are applicable to all conditions. It is such considerations as the above which make the economics of manuring old Rubber so difficult.

BUDDED RUBBER

Fortunately, up to or near the bearing stage the costs of manuring are relatively so much less that this greatly simplifies the economic problem. For the first few years at any rate one can apply ample amounts of all three elements at a cost representing a very small proportion of the loss in profits and expense of replanting.

I propose, therefore, discussing some general aspects of manuring young Rubber. A common recommendation is to mix manure with the filling earth. When, and on what grounds is this advisable?

(a). Either organic or inorganic nitrogen, in our conditions, becomes rapidly converted and leached away if not taken up.

(b). Holing and filling can usually be most economically done, and the work got on with in ample time, during the autumn months while the trees are being drastically tapped, thus reducing the labour rush to prepare for South-West planting.

This has much to recommend it. But, surely, to apply rapidly leachable nitrogen to holes which will not be planted until 8 or 9 months later must be wasteful.

(c). If budded stumps in an early stage of growth are examined the following facts emerge:—
The bud shoots put out its first whorl of leaves. These have grown from the food reserves in the stock and the water supplied by the taproot. In practically every such case it will be found, on uprooting, that though tap rootlets may have started, the laterals have not yet. It would appear that usually the taproot, at this stage, supplies the first leaves with water and solutes.

Some people still believe that the taproot is practically incapable of absorbing manure. The two planting seasons — South West and North East are usually followed by a period of drought. By then, as previously mentioned, the first whorl of leaf growth has preceded the laterals. This is a critical time in the life of a young clearing. It is clear that. in this state, the only moisture which can replace evaporation from the leaves must enter *via* the taproot. The small amount in the stock could not keep the plant alive for more than a few days. But, though the plant probably survives, the leaves remain yellow, and exposed to weak parasites for a long time. It is then that, say 4 ozs. of soluble N.P.K. works wonders and is quick visible proof that the taproot can and does take up manure. In two or three weeks the leaves are dark-green and lateral root growth soon develops. It should be followed up within 6 weeks to 2 months with another 4 ozs. I think that at both these stages it is safer not to fork, but only very lightly to scratch in the manure, if at all, otherwise any precious lateral may get broken. For this reason also we do not use organics.

This question of lateral root and shoot growth is so connected with effective manuring that some other points seem worth attention. I have mentioned the usual manner in which the bud canopy precedes lateral root growth. It is sometimes accepted that this is inseparable from the normal process of plant growth. This has resulted in two practices (a) to allow stock buds to shoot, with a view to promoting root growth, and then to cut these off when it is believed that sufficient laterals have been developed to support the bud. To find out about this we planted a trench with budded stumps. Odd numbers were

allowed to put out top shoots; even numbers had top stock buds cut off as soon as they appeared. When the odd numbers had developed their first stock canopy this was cut off. The subsequently developed bud-shoots were relatively poor. Presumably the stock leaves had exhausted the starch content of the stock, which, later, was barely sufficient to grow the dormant bud up to the effective photo-synthetic stage of leaf growth. Leaving top shoots to grow temporarily would, therefore, seem unsound. The longer stock also increases desiccation and adds to the expense of shading.

(b). Another common practice is to "ring" the stock some days before transplanting with a view to encouraging the bud to shoot quickly. In view of previous remarks, is this right?

If, as often happens, a drought follows planting, which would be preferable, — to have leaves developed before there are adequate laterals to support them, *or to develop a root system which precedes and can support the foliage?* The latter course would clearly be preferable if it could be effected.

These considerations led me to think that we were putting the cart before the horse. We, therefore, severed the laterals of dormant bud stocks in the nursery with a sharp alavango, some 6 inches away from the stock, a fortnight and three weeks before planting. The callousing over of the severed roots was periodically examined. It was found that the roots were ready to get on with new growth between those times. 100 transplants thus treated came on more quickly and were sooner ready for manure than ordinary budded stumps.

This raises a further point. If the rapid development of lateral root growth is of primary importance in conjunction with the earliest possible manuring, and supposing for the moment that the severance of laterals at some period before replanting may be preferable to present methods, what further steps, if any, could we take to encourage root growth after transplanting?

Clearly, to sever the lateral roots of starved hide bound young plants 18 days before transplanting would merely be a further handicap, but we know that a vigorous free-growing plant will survive when the sick yellow one dies. Root growth we know, is intimately connected with cambial growth — that sheath of living creative tissue which envelopes a plant from root tip to topmost shoot. Apart from the intriguing problems of the use of plant hormones, we know that a liberal dose of

nitrogen produces free succulent growth. Surely the answer to this is to get our nursery plants filled to their limit with nitrogen, and if necessary with phosphorous and potash, before transplanting, so as to ensure that manurially, they have the best possible start.

From then onwards the usual procedure is to give increased doses of 6 to 8 ozs. of an N.P.K. mix at 6 monthly intervals for the first two years. Perusal of various research station publications will give you all that.

But a further practical point is that of selective manuring. Short of failure there is nothing worse than an uneven clearing. There will always be some plants which grow dangerously tall and others in various degrees of backwardness or failure.

A common practice is to give the big plants a big dose and the small ones less, or to give an equal amount to all. This is dangerous and wasteful. Better practice, is to leave out all plants over a certain height. The rest are manured with whatever dose is considered necessary. All supplies or backward plants below a certain standard are then marked with a tall bamboo carrying a strip of cloth. At a subsequent date they are selectively given another dose. Those which still fail to respond are rooted out and replaced. The successful new clearing planter, should, I think, be rather like Father O'Flynn "driving the lazy ones on with a stick."

ACID OR BASIC MIXES?

The Research Scheme advises a mix containing cyanamide, which, of course, is basic and my impression from a number of trials, though these were not laid out for statistical comparison, is that they give better results than say sulphate of ammonia or Nicifos as a vehicle of nitrogen in the South West acid soil zone. In the drier parts of Uva, on the other hand, where we used No. 2 Nicifos, principally because of economy of transport, results have been strikingly good. We did not use basic mixtures there because the soil is more alkaline. In two dry districts in India Nicifos has given excellent results, whereas in a very wet district it has been disappointing.

PHOSPHORIC AND POTASH

Mr. Keiller did sterling work on young Rubber many years ago when he showed the importance of phosphoric, which is now realized to be of importance. Space forbids my detailing

experiments and observations on old Rubber which gave me the impression that potash was unnecessary, even on young Rubber.

Mr. Murray returned from the Straits with a conviction that the importance of potash had been underestimated. It is only fair to tell you that, in the light of previous experience, I disagreed with him. On an estate I am connected with we divided a 3½ acre clearing in half. It was planted with a mixture of Tj. 1, and B.D. 5 on a rather poor separate "Godella" or hillock. The left hand half was manured with an adequate dose of N.P. and the right hand with N.P.K., *i.e.*, addition of potash. Girth measurements were taken. The results are as follows:—

Since the experiment was started in April 1936, up to October, 1938, the N.P. trees had increased 8.25 inches, whereas the N.P.K. trees had increased 9.71 inches. Apart from any statistical test no visitor, uninformed as to which was which, has failed to discriminate in favour of the cum-potash block. With each subsequent measurement the divergence in favour of potash has increased.

I would finally descibe a small experiment at Mirishena which is proving of interest.

In 1935 a field was planted part with Tj. 1 and part with Hillcroft 28. In March, 1936, 10 blocks of 20 trees each were chosen along separate platforms in the Tj. area and 10 in the Hillcroft. Two blocks in each area were manured with each of the following:—

No. 1.—Animal meal made up with S.A. and muriate, to a 10:10:10 ratio.

No. 2.—Sulphate of ammonia and Safaga phosphate giving 10:10 of N. and P.

No. 3.—Sulphate of ammonia and muriate, giving 10:10 of N. and K.

No. 4.—Sulphate of ammonia, Safaga and muriate, giving 10:10:10 of N.P.K.

No. 5.—The controls were given the ordinary N. P. field manure.

The objects of the experiment were (a) to test the relative value of 1 and 4, organic versus inorganic complete mix, and (b) the relative values of nitrogen and phosphoric only, and nitrogen and potash only compared with a complete N.P.K. mix.

Every tree was numbered and had a white ring painted round it for girth measurements at 3 feet. Girths were taken every 3 months. Two applications were given in March and August, 1936, and a third in October, 1937. Measurements were again taken in April, 1938, by when the average girths were over 8 inches.

The following were the increases in inches for the two years:—

	No. 1 A.M.	No. 2 N.P.	No. 3 N.K.	No. 4 N.P.K.	No. 5 Controls
Tj. 1	5.00	4.38	5.00	5.12	4.80
H.C. 28	5.50	4.63	5.25	5.24	4.53

It will be noticed that the biggest increase is with animal meal on the Hillcroft 28, followed by N.K. and N.P.K. in that clone. The relative increase in the Tj. area has been less than any of these three, but N.P.K. may be considered at least as good as animal meal. In both clones the N.P. blocks have come out worse, tending to show a potash deficiency.

Considering the much greater cost of the animal meal, and the relatively small difference in its favour, it was decided to put the treatments on an equal money basis, taking the animal meal mix as the index.

					N.	P.	K.	
No. 1. A.M.	was given	2 lbs.	per tree	of a	12.6	13	12.6	mix.
No. 2. N.P.	,,	3.1	,,	,,	29	30	—	,,
No. 3. N.K.	,,	2.6	,,	,,	30	—	30	,,
No. 4. N.P.K.	,,	3	,,	,,	23	23	23	,,

It should be noticed that the inorganic N.P.K. mix gave for the same cost nearly double the amount of plant food contained in the made up organic mix, and two and a half times the amount was given by the N.P. and N.K. doses.

The last measurements taken, six months after the altered application, in October, 1938, gave the following increases for the 6 months.

	A.M.	N.P.	N.K.	N.P.K.	Controls
Tj. 1	2.37	2.37	2.62	3.13	2.13
H.C. 28	2.75	2.12	2.75	2.75	2.12

These figures, for what they are worth, tend to emphasize the relatively poor response of both clones in this soil to mixtures lacking potash. They also tend to show that on an equal money basis the N.P.K. inorganic mix has already caught up on the organic in Hillcroft 28 and has far surpassed it in the Tj. area.

DISCUSSION

Mr. P. A. Keiller said that he was surprised at Mr. Bertrand's results with regard to forking and wash. His experience was that forked land stood up very well against rain and suffered less from wash than unforked land. Root exposure, due to wash, was much more in evidence on the hard, unforked paths in his experimental Rubber than on the plots themselves. The soil was typical hard "cabook," but the plots had been very thoroughly forked until a loose surface was established, and this was now permanently loose. He added that he was not greatly in favour of forking Rubber land and preferred Rubber under a permanent cover crop. He suggested that if forking had to be done it would be best to fork during the monsoon, when the soil was workable, and to broadcast manure in February-March without further forking.

Mr. Keiller further remarked that he was also surprised at the good results got by Mr. Bertrand and others by the use of cyanamide. He had seen Mr. Bertrand's Rubber manured with cyanamide and it was excellent, and he had seen similar results elsewhere, but he himself had not had good results from this source of nitrogen. His cyanamide plots were uniformly poor. In his case, however, the cyanamide had been used from the start, when the Rubber was first planted, and had been applied annually for about 24 years. He did not think there was any danger of the soil becoming too acid for Rubber through the continued use of sulphate of ammonia.

With regard to the response of young budded Rubber to potash Mr. Keiller said he thought this was because the Rubber was young and not because it was budded. It was likely that any young plant would respond to the application of all plant foods in an available form because they had no extensive root system with which to search for food. He was still doubtful whether it paid to apply potash fertilisers to old Rubber.

Mr. Keiller stated that he was not in favour of cutting the lateral roots when transplanting.

Mr. Bertrand in reply expressed the opinion that the South-West monsoon was a most unsuitable time for manuring.

Mr. P. R. May said that his experience of cyanamide had been most unfortunate. Some years ago when the cyanamide mixture as recommended by the Rubber Research Station was applied to holes at the time of planting approximately 2,000 of 3,000 budded stumps had died. Again this year he tried it on young plants with the budshoot 2 to 3 months old. A good many of them turned yellow. He found by substituting sulphate of ammonia for cyanamide in the mixture that results have been far more satisfactory. He had by far the best results for budded Rubber up to two to three years old from a mixture recommended by the Rubber Research Scheme a few years ago composed as follows:—

1 part sulphate of ammonia

3 parts blood meal

5 parts bone meal

1 part muriate of potash

10

Mr. W. R. Thomson criticised Mr. Bertrand's recommendation that the filling of the nitrogen requirement in mature Rubber without attention to other plant foods was the correct way to start manuring old Rubber. The quantity of nitrogen recommended to be used tended to be unnecessarily large and while it often gave a satisfying eye effect the eye was not necessarily the final arbiter. In any case complete mixtures often gave the same or better eye effect from much less nitrogen and there were indications that a healthier type of growth resulted.

Mr. Bertrand had criticised the use of manure in the planting holes. Whatever the fate of nitrogen when applied at an interval before planting the opportunity of placing phosphate and potash where they belonged well down in the soil was one which only occurred at planting time in the possibly 40 years of the tree's life and surely it was right to take advantage of the infrequent opportunity.

Mr. C. A. de Silva questioned the desirability of broadcasting calcium cyanamide on the grounds that there might be a loss of ammonia on contact with light rain or dew. He said that his argument was only a theoretical one and hoped that one of the fertiliser experts present would give his views.

He also stated that the results of an experiment in progress on Dartonfield confirmed Mr. Bertrand's findings that on an equal nutrient basis an inorganic mixture gave as good results as an organic mixture, while the former was, of course, much cheaper. He added that in the case of both treatments large quantities of organic material had been incorporated with the soil in the form of green manure loppings.

In reply, Mr. Bertrand said he understood that normally the first decomposition product of cyanamide was urea, and that this would be quickly absorbed into the soil. If any ammonia did escape from broadcasted cyanamide he had certainly never smelt it.

Mr. R. K. S. Murray said that having had the opportunity of seeing an advance copy of Mr. Bertrand's interesting paper he had made notes on several points for discussion, but some of them had already been dealt with by previous speakers. He agreed that forking old Rubber was usually undesirable and should be avoided if possible, but thought that in certain circumstances, notably in the drier districts where the soil sometimes becomes very caked and hard, the use of the fork might be necessary as a preliminary to the establishment of a cover crop, after which forking would be unnecessary.

Mr. Murray agreed with Mr. Thomson's views on the correct way to resume manuring mature Rubber which had not been treated for some years. He considered that rather than apply 80 lbs. of nitrogen per acre in one dose it would be wiser to apply 40 lbs. in each of two successive years. Mr. Bertrand had spoken about a lower limit to the effective dose, but on Dartonfield a visual response had been shown to a single application of 40 lbs. on land that had not been manured for several

years. He also considered that it was wise to remedy any possible mineral deficiencies as early as possible and not delay the application of phosphate and potash as suggested by Mr Bertrand. These nutrients were less fugitive than nitrogen and there was therefore less risk of loss if they were applied before the trees were in a condition to take them up. Moreover, when resuming a manuring programme one of the primary objects was often the establishment of a cover, and for this purpose phosphate, and possibly potash in some circumstances, was necessary.

Referring to Mr. Bertrand's remarks on the early rooting of transplanted budded stumps, Mr. Murray said that he had found young rootlets several inches long produced from the old laterals about 6 weeks after planting. Although it was true that the first whorl of leaves precedes the formation of new laterals, the latter should be functioning by the time the inter-monsoonal dry seasons are experienced. Mr. Murray doubted whether Mr. Bertrand's suggestion of cutting the laterals two or three weeks before planting would be of value, for it was largely the existence of the foliage which stimulated the production of roots.

Mr. Murray suggested that Mr. May's unfortunate experience with a cyanamide mixture applied at the time of planting might be the consequence of insufficient mixing with the soil.

PESTS IN RUBBER REPLANTED AREAS

E. C. K. MINOR

(GOVINNA ESTATE)

I do not propose to deal with all the pests of the Rubber tree, nor would it be of much value as many of them are of little importance.

The ones that chiefly concern us in these days of Replanting are those in our nurseries and new clearings, and by far the most important, on account of the destruction they cause, are the Leucopholis, or as it is better known *Lepidiota pinguis* grub — a Cockchafer grub, and slugs and snails.

Dealing first with the Lepidiota:—

Soon after rubber nurseries have been planted up or seed at stake in holes in the field, it will very often be noticed that some of the seedlings have wilted or fallen.

It was in September, 1936, that I saw some seedlings in two new nurseries, one at Govinna estate and the other at Mirishena, slanting and wilting and some lying on the ground. When pulled up the roots were seen to have been chewed off ½ inch to an inch below ground level. In many cases it was noticed that the damage done was quite fresh, and by digging round about where the seedling had been, though sometimes necessary to a depth of over a foot, a large white grub was found. I sent some of these grubs to Dr. J. C. Hutson, the Entomologist of the Department of Agriculture, for identification, and I am much indebted to him for many facts of the life history of this insect which I shall mention later. Dr. Hutson visited Govinna and Mirishena estates, and also Frocester estate which had suffered a lot from the grub attack in holes where seed at stake had been planted.

This pest is dealt with in Petch's book "Diseases and Pests of the Rubber Tree" and in Sharples' book of the same name and in our and the Malayan Rubber Research and other agri-

cultural publications. In other parts of the world it is reported on various crops, and in Ceylon also on Tea, Cinnamon and Coffee.

I mentioned before that the damage done by the grub is to chew off the taproot of a Rubber seedling just below ground level and, in consequence, very often the plant dies. Sometimes, if it is growing vigorously, numerous side roots are sent out to take the place of the lost taproot and the plant may live, but it has had a bad setback and such plants can easily be picked out in an old nursery; when these are pulled up the multiple roots are seen. If action is not taken at once in an infested nursery great loss will result. Constant and careful supervision is necessary; a week's delay and untold damage is done.

Since September, 1936, on Govinna and Mirishena estates 2,301 grubs have been caught and killed, and 1,083 seedlings destroyed. On a neighbouring estate about 10,000 grubs have been killed and 50 per cent plants destroyed. On another estate in the district the figures are 4,000 grubs. I have also heard of much damage done in other districts.

I have specimens of the various stages of this insect in boxes and test tubes here for anyone who would care to examine them, and I am obliged to Mr. Henry of the Colombo Museum for kindly supplying me with many of the specimens.

A short life history of the pest is as follows:—

The beetles emerge from their underground pupal cells when the soil is softened by the first South West monsoon rains, say in March, April and May. What they feed on is not known for certain, possibly on mango and ficus; they have been reported on Dadaps in the low-country and Acacias up-country; but they do very little damage. They lay their eggs in loose, friable soil. It very often happens that nurseries in peaty, boggy soil found in low-lying ground near a deniya are not infested with the grub.

In about a fortnight the grubs hatch out from the eggs. It is these grubs which feed on young Rubber roots. They grow to a size of about 2½ inches, they burrow deeper into the soil and there form a loose cocoon in which they pupate. This happens towards the end of the year. From the cocoons eventually the beetle emerges in the following year.

The periods just mentioned are by no means strictly followed, as often active grubs are found in January; these probably are hatchings of late egg layings. Weather conditions, especially drought and moisture, have an important influence on the life cycle.

I may mention that there is another grub often seen in rotting wood, such as firewood dumps and fallen decaying trees — note that this grub is found in *dead* and *decaying* wood and does not eat living roots, and so is harmless to our Rubber seedlings; it looks very much like Lepidiota; it is the grub of the Coconut Black Beetle or the Rhinoceros Beetle.

If looked at closely these grubs are distinguished as follows:—

Just behind the head is seen a dark yellow mark, the lateral thoracic plate. In the Lepidiota it is long and narrow, and in the Rhinoceros Grub broad and somewhat quadrangular. I show this in this diagram. [Not reproduced. Diagrams were published in the R. R. S. *Quarterly Circular*, Vol. 14, December, 1937, facing page 43.]

Other distinguishing features are the number and arrangement of hairs on the last or anal segment of the body; in the Lepidiota the hairs are more numerous; the arrangement is shown in this diagram. [See above.]

PREVENTATIVE MEASURES

In our nurseries we have tried many of the soil fumigants on the local market, but none of them have proved very efficient; the large grubs appear not to be affected by them. Perhaps if the fumigant is incorporated with the soil when a nursery is being made it would kill the grubs which had just hatched out at that time, but then there are the grubs which hatch out later, and by then the strength of the fumigant would have lessened and fresh applications would be necessary, with possible mechanical damage to the roots of the seedlings during application.

The most successful method we have found is constant supervision and, when an attacked plant is seen, to dig all round, even removing surrounding untouched seedlings, until the grub is found, and then destroying it. When forking over a nursery any grubs seen in the soil should be collected and destroyed.

Great care has to be taken in the case of clonal seedlings, their value being so much in comparison with ordinary seedlings.

A successful dodge is to plant in a circle round the clonal seedling some ordinary Rubber seedlings, the grub will probably attack the roots of these first and its presence then would become known, and a search for it made. The ordinary seedlings would be removed when possible attacks by the grubs have ceased.

In the 1937 Annual Report of the Rubber Research Institute of Malaya there is mentioned a method giving 100 per cent kill of grubs. It is by using a machine known as a soil injector, which is designed to deliver small and measured doses of carbon bisulphide at the rate of one 10-gram dose per square foot. The cost is unfortunately high — they give an all-in cost of about Rs. 225 per acre. Carbon bisulphide cannot be bought in large quantities at present in Ceylon; and its cost is Rs. 20 per gallon.

Carbon tetrachloride is also quoted by the Rubber Research Institute of Malaya to be effective, but not so efficient as the bisulphide. It may be mentioned that the chief species of the Cockchafer grub in Malaya is *Psilopholis grandis*. I believe it is very similar to our grub but has not yet been reported in Ceylon. It is known to attack Rubber up to 3 years old and over. The oldest Rubber I have seen attacked by Lepidiota was a $1\frac{1}{2}$ year budded stump, part of the taproot of which had been eaten away.

Light traps are not of much use against the beetles as they do not seem to be attracted much by light.

The Green Muscardine Fungus, Metarrhizium, which parasitizes the coconut beetle grub might also infect Lepidiota. It is not easy to carry out controlled experiments under estate practice to prove this — in any case the attack would have to be quick to overpower the grub before it lived many days, otherwise it could do damage in the meantime. As this fungus occurs naturally in some Ceylon soils it is doubtful if it would be very successful.

In Malaya two primary parasites are known — these are two Scoliid wasps. In both cases the female wasp deposits an egg on the well grown grub and the latter is devoured in a few days after the wasp larva has hatched. Similar species of wasp are found in Ceylon, (I have specimens here), but I have never seen a grub so attacked.

The other important pests met with in our clearings are slugs and snails.

When budded Rubber gets about six months old some of the grafts are seen to end in a long spike with no leaves at all for

a length of about $1\frac{1}{2}$ to 2 feet from the top. The leaves growing lower down very often show signs of having parts eaten out of them. This is typical of an attack by slugs and snails, the damage at the top of the plant is most probably due to the slug alone; I have seen slugs up there but have not seen a snail so high up, possibly they cannot climb so small a stem.

Apart from eating any young tender leaves and occasionally a thin strip of the outside of the green part of the stem, there appears to be something, which most probably is a natural secretion of the slug, which holds back growth of the plant so attacked and it remains in this state for quite a long time in spite of extra doses of manure.

On an estate in the district the slug attack this year was very bad. A check on the slugs collected was kept by weight and it was calculated that in one month 14,400 slugs were collected and destroyed.

Slugs and snails do most of their damage at night.

There is on the market a product called Meta which is a most virulent posion to slugs and snails. Meta is the trade name for Metaldehyde, it is also known as "Solid Fuel." It is sold in packets of $7\frac{1}{2}$ ozs. at Re. 1 per packet, and looks like rectangular pieces of chalk.

A good way to meet an infestation of slugs and snails is first of all to send out podians for two or three mornings to hand pick what they can find. Then a Meta-bran mixture is made as follows: $\frac{1}{2}$ oz. of Meta, finely powdered, is well mixed with 1 pound of rice bran in a little water. A little rice congee water is added so that when the mixture is kneaded into balls about the size of a golf ball they will retain that shape. One such ball is placed close to the base of a graft which has been attacked, and over the ball is put a piece of broken country tile to protect it from the weather.

Next morning one is almost sure to find, all within a foot of the Meta-bran, dead or dying slugs and snails. Hardly any of the ball is eaten, the very slightest trace of the Meta would appear to be enough to kill the slugs. The slugs and snails emit a lot of froth before they die, and should be removed from round the ball each morning. The bait will be effective for about a week. I have heard, but have not tried it, that Meta, sprinkled on newspaper is very effective.

The cost of the Meta-bran bait method works out at 1.13 cents a ball. If there are still a number of fresh snails being killed each day then another round of the bait should be put out, after that a 5 per cent mixture of "Atlas" wood preservative in lime, made into a thick paste, and dabbed on to the underside of bits of overhanging rocks or the underside of the country tiles and placed all over the infested area, will keep down further infestations of the snails.

As for other pests there are lizards (*Katussas*), crows flying off with seeds from nurseries, rats and bandicoots, and numerous others with which you are acquainted and about which it is not necessary to speak.

DISCUSSION

Mr. V. Roe enquired whether "Meta" had been tried against the Lepidiota grub.

Mr. Minor replied that it could not be used in the form of a "Meat-bran" mix as the Lepidiota grub lived underground.

Mr. Roe said he wished to know if experiments had been carried out mixing "Meta" in the soil of a nursery or planting hole against the grub and, if so, had it been found poisonous to the young Rubber.

Mr. Minor replied that he had not carried out such experiments, chiefly because "Meta" was an expensive substance. He did not think it would be poisonous or injurious in small quantities to young Rubber.

Mr. R. K. S. Murray said that he believed a demonstration of a cyanide fumigation method for the destruction of bandicoots had recently been given on an estate, and he hoped that someone who was present would give his views about it.

Mr. G. B. Foote said that he was present. A cage containing live rats was brought and put at one end of a specially constructed burrow. A glass fittted at one end gave a clear view of the result of the fumigation, and from what he saw he thought that the method would be very effective.

Mr. Murray drew attention to the fact that Imperial Chemical Industries (India) Ltd. were importing carbon bisulphide in bulk at a price less than one-third that mentioned by the lecturer.

MODERN DEVELOPMENTS IN THE PREPARATION OF PLANTATION RUBBER

T. E. H. O'BRIEN

DIRECTOR

(RUBBER RESEARCH SCHEME)

RELATIVELY slow progress has been made in the modernisation of factory equipment on Rubber estates in Ceylon in recent years. During the slump years from 1930 onwards no funds were available for this type of expenditure and when conditions improved, attention was, quite rightly, first turned to the task of making up leeway in the cultivation of the estates. During the past two years replanting has usually taken first place in the allocation of available funds.

In other rubber producing countries there was a tendency during the slump to lay out capital on the modernisation of factory equipment with a view to the reduction of working expenses. This was a very sound move on the part of companies with ample reserves, since the cost of engineering materials and services was then at a minimum but it is thought that reserves were sometimes unduly depleted in an attempt to show a profit on working account. Generally speaking Ceylon producers conserved their resources as far as possible during the period.

I propose to give a very brief resumé of some of the modern developments in factory technique and equipment in relation to the preparation of smoked sheet and crepe and then to refer to a few of the alternative forms in which raw rubber can be, or is being, prepared.

The general tendency in recent years in other countries has been to replace small divisional factories by a central unit for each estate or group of estates, so designed as to reduce power and labour requirements to a minimum. Almost invariably smoked sheet is the product made. Individual sheeting mills

have been replaced by line-ahead batteries of 4, 5, or 6 rollers, some of them with a reported output as high as 2,500 lbs. per hour. Coagulating pans were superseded years ago, on large estates, by tanks in which strips of coagulum are formed by the insertion of vertical partitions at suitable intervals. As a development of this method the partitions are now so arranged as to form a continuous strip of coagulum which can be fed to the sheeting mill with a minimum of handling. The tanks are usually mounted on rails and can be moved in turn to a position close to the sheeting battery. On one group of estates in French Indo-China the strip of coagulum is formed in a novel way. Coagulation is carried out in a cylindrical tank. The block of coagulum, mounted on a central spindle, is then rotated on a longitudinal axis and cut by means of a band saw into a continuous strip, on the same principle as cutting timber for plywood.

The wet sheets, after being cut into pieces of suitable size are hung on trolleys, also on rails, and pushed into the smokehouse after a suitable interval for draining. The smokehouse may consist of a separate compartment for each day's crop or may be of the type in which the trolleys enter at one end and are moved forward each day until they emerge at the other end. The trolleys then continue their journey to the packing room. The thickness of the sheets is adjusted so that the period required for smoking does not exceed four days.

The question arises how far such "mass production" methods can usefully be applied on the relatively small estates which are common in Ceylon. It would obviously be absurd to instal a battery with a large output on an estate with a daily crop of a few hundred pounds but I consider that the installation of a small battery and the adoption of generally more efficient methods could usefully be considered on estates where the daily crop exceeds 1,000 lbs. It is also believed that substantial economies could be effected by the provision of central factories serving a number of small neighbouring estates. Such a move would have a very valuable effect in improving the uniformity of the product. It may be of interest to mention that a smoked sheet factory designed on the latest "mass production" lines has just been erected on a local estate. I had the pleasure of visiting it recently and was much impressed with the layout.

Sheeting equipment is considerably cheaper to instal and maintain than creping machinery and this factor has had an

obvious influence in determining the adoption of smoked sheet as the predominant plantation product. There is, however, a steady demand for crepe rubber for certain purposes and the law of supply and demand has led to a substantial premium for crepe being maintained for some time past. In my opinion estate proprietors with the necessary resources to instal and maintain efficient creping machinery will earn a good return on their outlay over a period of years.

HANDLING OF LATEX

The centralisation of factories has led to the more extensive use of lorry transport for the delivery of latex to the factory and there is no objection to such transport for very considerable distances, provided the latex is kept in good condition by the addition of an anti-coagulant. Sodium sulphite is generally used for the purpose in Malaya; in Sumatra the use of ammonia is favoured. The latter material is also preferred by the present speaker.

The contamination of latex with grit is inevitable under estate conditions but it is now recognised that all except the finest particles can be eliminated by allowing the diluted latex to stand in a settling tank for an hour before being transferred to the coagulating tanks. The settling tank which is preferably lined with glazed tiles, is provided with a bottom which slopes back from the outlet pipe or the outlet is slightly raised, so that a small quantity of latex containing the sediment is left behind when the bulk of the latex is run off. This latex can be coagulated with bucket washings, etc., or resettled in a smaller tank.

The conventional latex strainer as commonly used in Ceylon has been replaced by a more efficient type of straining box in which the latex passes upwards or sideways through the mesh, which is kept immersed in the latex. The use of brass gauze leads to the risk of copper contamination of the latex and it is being replaced by monel metal or nickel gauze on all progressive estates.

COAGULATING TANKS

Aluminium lined tanks are commonly used in smoked sheet manufacture. In Sumatra ebonite sheets made from uncouponed rubber are being used for the purpose and it is stated that the

cost is less than that of aluminium. There would be no difficulty in making this material in Ceylon if the necessary equipment was available. Glass lined tanks with glass partitions are marketed by a local company. They are substantially cheaper than aluminium tanks but are obviously open to the risk of mechanical damage.

Aluminium lined tanks are equally suitable for crepe coagulation but the local producer would probably continue to use Shanghai jars for the purpose if he was faced with the expense of replacing them by aluminium tanks. Masonry tanks lined with glazed tiles jointed with a mixture of cement and water-glass, are largely used for the purpose and are moderately satisfactory. The tiles are liable to become discoloured and the joints require re-pointing at intervals. The use of aluminium partitions for dividing the coagulum into slabs of suitable thickness for milling prevents damage to the tiles arising from the use of knives in cutting up the coagulum. Trials have been made at Dartonfield with various protective paints for surfacing cement lined tanks but none of them has proved satisfactory up to the present.

MILLING

It is not proposed to discuss the merits of different sheeting batteries but it may be of interest to recall that what was probably the first line-ahead battery was designed and marketed in Ceylon as the "Hoare multiple sheet roller" some 15 years ago. These machines were installed on a number of local estates and some of them are still giving moderately satisfactory service.

The main development to be recorded in creping machinery is an increase in the width of the rolls from 15 or 18 inches to 22, 24 or 26 inches and in the diameter of the rolls from 12 to 14 inches or more. A massive type of construction has been adopted to withstand the hard use which the machines receive. Investigations undertaken by the Research Scheme some years ago established the fact that the gripping power of the rolls depends mainly on the texture of the roller surface. Chilled iron becomes polished in use and has poor gripping powers, whereas coarse grained cast iron tends to roughen with use and maintains a relatively high efficiency. This material should always be specified for smooth creping mills. Chilled iron is probably to be preferred for grooved mills owing to its better wearing properties.

Reference has already been made to the type of smoke-house favoured in modern "mass production" factories. In Ceylon developments have been on different lines, attention having been chiefly directed to securing the greatest possible economy in firewood consumption. At the present time, owing to replanting operations, firewood supplies are abundant but up to a few years ago supplies were scarce and the price was high. Our smokehouses are usually of the 3-storey type and are very economical of fuel but it must be admitted that they leave a good deal to be desired in regard to ease of handling the rubber. The advisability of adopting the single-storey type of smokehouse with racks on trolleys will depend on such factors as the availability of cheap firewood and the size of crop to be handled.

In the past it has been customary in Ceylon to air-dry crepe rubber in lofts over the factories but it is now fairly generally recognised that the local climate in most rubber producing districts is unsuitable for natural air-drying owing to the prolonged spells of wet weather, during which the crepe is liable to become discoloured with surface mould. The most usual method of assisted air-drying is to provide an air heater and a fan which blows the warm air through a sealed drying room. Trials carried out by the Research Scheme have led to the development of a drying system in which a building of the smokehouse type is heated by means of hot water radiators in the base of the building. Drying is completed in 3 days at a temperature of 95°F., after 1 day's normal air-drying. An advantage of the system is that no power is required and drying can be continued at night. A small unit has been in use successfully at Dartonfield for several years and a building designed to deal with a daily crop of 3,000 lbs. is giving satisfaction on a near-by estate. In designing a new crepe factory it would be relatively easy to arrange for the crepe to be passed through a warm air-drying house, on trolleys.

PACKING

Formerly plantation rubber was almost invariably shipped in plank or plywood packing chests but in recent years an increasing proportion has been shipped in bales wrapped with hessian or matting, according to the country of origin. The change has been made partly from motives of economy and partly owing to manufacturers' complaints of wood splinters in the rubber. At present the general position is understood to be that most of the rubber shipped direct to consumers is sent forward in bales

of one sort or another, whereas rubber which is to be re-sold on the open market is usually shipped in chests, owing to dealers' prejudices and the greater difficulty of sampling baled rubber.

As far as Ceylon is concerned most of the rubber is now sent from the estates to Colombo by motor lorry either in open bundles tied with coir rope or in coir wrappers. This practice was started during the depression but is likely to be continued as shippers prefer to do their own packing, either in bales or plywood chests, according to requirements. This method of transport is quite sound, provided the necessary simple precautions are taken to keep the rubber clean during transit. If coir wrappers are used they should be lined with fabric to prevent the rubber being contaminated with fibre. Coir rope should be treated with a size made from flour and sodium silicate for the same reason. If the rubber is sent in open bundles dust sheets should be provided to lay on the floor of the lorry and to cover the rubber.

ALTERNATIVE FORMS OF RAW RUBBER

I have given you a very brief resumé of developments in the preparation of smoked sheet and crepe and will now deal even more briefly with some alternative forms of preparation. A few years ago questions were frequently raised regarding the possibility of existing methods of preparation being superseded but I think it is now more generally understood that smoked sheet and crepe are likely to remain the standard plantation products for many years to come.

LATEX SHIPMENT

The quantity of raw rubber shipped in the form of fluid latex has increased in the last 10 years from 3,600 tons to 34,500 tons. The rate of increase is very high and latex exports may be expected to continue to expand but it will be many years before they represent a substantial proportion of the total output of raw rubber. Field latex of 38-40 per cent D.R.C., preserved with ammonia, is still shipped for certain purposes but the bulk of the present demand is for concentrated latex. There are three basic methods of concentration, each of which is, or was, covered by patent restrictions, namely: the Utermark process for concentrating by centrifuging in a machine of the milk separator type; the Traube process for concentrating by chemical creaming with vegetable mucilages; and the Revertex process for concentrating by evaporation. The Dunlop Company,

working under the Utermark patent, have made very large shipments of latex concentrated to 60 per cent D.R.C. in recent years. They have extensive storage installations at Singapore and Liverpool and their shipments are made by tank steamer.

The Utermark and Traube patents have now lapsed in Ceylon and will do so in most consuming countries within the next two years. Experimental work on these methods of concentration has been undertaken by the Research Scheme and advice can be given to local producers who wish to make use of them commercially. It is possible that a useful demand for the products can be developed in India.

RUBBER WITH LOW WATER ABSORPTION

Although rubber is used extensively as an insulating material in the electrical industry its usefulness in certain directions, notably in the construction of submarine cables, is limited by the fact that moisture absorption is sufficiently high to impair the insulating value of the material. The absorption of moisture was originally attributed to the protein content of the rubber but is now recognised to be partially due to water-soluble substances which are present. Various methods have been used for improving the electrical properties of rubber, the most practical being those which depend on the removal of proteins and water-solubles from the latex by multiple creaming or centrifuging, in some cases preceded by treatment with caustic soda or a proteolytic enzyme such as papain. A commercial demand for this special grade of rubber already exists and is likely to expand. It may, however, be mentioned that the position in regard to patent rights is rather obscure. The Research Scheme has already sent several experimenal consignments of low moisture absorptive rubber to London for experimental purposes.

RUBBER CRUMB AND POWDER

Publicity which was given a few years ago to processes for the preparation in crumb or powder form led many people to believe that this type of product would rapidly replace smoked sheet and crepe as the standard plantation product. The materials are, however, still in an experimental stage and there appears to be no present prospect of an extensive demand for them arising.

NITRITE CRUMB

The Research Scheme, in conjunction with the London Advisory Committee for Rubber Research, has developed a special form of crumb rubber which is prepared by treating the

latex with sodium nitrite before coagulation. It is a modified rubber and is not suitable for the manufacture of vulcanised products but has the interesting property of forming solutions of low viscosity when treated with organic solvents. This property led to trials of the material for addition to asphalt in small quantities with a view to modifying the properties of road surfacing compositions. So far as present observations go it seems probable that a small proportion of rubber dissolved in asphalt improves the non-skid properties of road surfaces by reducing the flow of the asphalt, but it is uncertain whether nitrite crumb has special advantages for the purpose over other forms of rubber. A new series of comparative road trials has recently been laid down in England and the results will probably determine whether a commercial demand for the product is likely to arise. Provided that raw rubber in some form finds a use in the manufacture of asphaltic road compositions it does not greatly matter what form is used but it would be gratifying if nitrite crumb was found to be especially suitable. A total of approximately 10 tons has been shipped from Dartonfield during the past few years and a satisfactory manufacturing technique has been worked out.

That concludes my brief survey of modern developments in the preparation of plantation rubber and I shall be very glad to answer any questions arising from the paper.

DISCUSSION

Mr. May enquired what the difference in output was between the old 15-inch smooth crepe mills and the more modern 26-inch mills.

Mr. O'Brien said that the old 15-inch mills had an output of 100 to 110 lbs. per hour under favourable conditions. The 26-inch mill at Dartonfield had an output of 180 lbs. working relatively slowly.

Mr. Healey enquired whether latex from three or four day tapping was more liable to discoloration than latex from two day tapping.

Mr. O'Brien said that crepe had a deeper natural colour when the tapping interval was greater. He would expect the latex to contain a higher proportion of organic substances. The crepe might, therefore, be slightly more susceptible to oxidation,

surface mould and fungal spots but he did know whether the difference showed up on estates.

In reply to another question Mr. O'Brien said that smoked sheet and crepe were equally suitable for general purposes. For special purposes such as for manufacture of light coloured articles, it was essential that the manufacturers should have crepe.

Mr. Kennedy asked why there was such a big difference in price between sheet and crepe.

Mr. O'Brien said he thought it was a matter of supply and demand. There had been a big change-over to sheet manufacture in Malaya.

Mr. Bentley Buckle asked whether it was preferable to use liquid ammonia or ammonia gas in the preservation of latex.

Mr. O'Brien said that gas was better and cheaper.

Mr. Gilliat asked whether the age of the Rubber tree had any effect on the uniformity of the crepe.

Mr. O'Brien said that the quality of the rubber improved with the age of the tree. That had been suggested as a reason for the superiority of Para (S. American) rubber for certain purposes. He could not say whether the uniformity of the Rubber improved.

THE PRINCIPLES OF PLANT BREEDING AND THEIR APPLICATION

DR. C. E. FORD

GENETICIST

(RUBBER RESEARCH SCHEME)

AS my time is so limited I will dispense with a formal introduction to my subject and commence by attempting to give an idea of the background of organised knowledge possessed by the plant breeder. This knowledge relates to the mechanisms of variation, reproduction and inheritance.

VARIATION

Variations between individuals of species always occur and in some cases may be very obvious, for example, the yields, leaf, and seed characters of rubber trees. These variations are caused by differences either in the environment or in the hereditary material. Variations caused by the environment are not inheritable; those determined by differences in the hereditary material are transmissible and form the basis upon which the plant breeder works.

REPRODUCTION

Inheritable variations are transmitted from parent to offspring at reproduction, which is of two kinds:—

(1) *Vegetative reproduction*, in which the offspring receive precisely the same hereditary material as is possessed by the parent organism. Families established in this way are clones.

(2) *Sexual reproduction*, in which the offspring arise from the union of male and female sexual cells each containing half of the *kinds* of hereditary materials possessed by the parents. Hence sexual reproduction provides a means for the reshuffling of the hereditary materials and the emergence of new types among the progeny. This reshuffling is brought about by a rather wonderful mechanism which I will attempt to describe.

The essential constituent of each parental sex cell is a body called the nucleus. Each nucleus is made up of a number of structures called chromosomes, which I may liken to strings of beads, each of which has its own particular function to perform. For simplicity, you may think of a particular bead, or gene, as responsible for the appearance of a particular character. For instance, gene 1 on chromosome A may produce red petal pigment.

At fertilization the male and female nuclei fuse together and later, by means of successive nuclear division, an exact copy of the fusion nucleus is distributed to every cell of the plant body. When a nucleus divides, all its contained chromosomes split along their length so that there is a precise division of all the genes into two. One half of each chromosome goes into each daughter nucleus and thus, as regards the genes it contains, each daughter nucleus is identical with the mother nucleus.

In sexual reproduction not only do the two parents each supply a nucleus, but each nucleus contains a very similar set of chromosomes, bearing a similar set of genes. So the chromosomes of an adult plant may be separated into similar pairs, and likewise the genes may be classed into pairs. The members of a gene pair may be alike, or they may differ slightly. When both are alike the organism is said to be homozygous, which means "not hybrid;" when they differ the organism is said to be Deterozygous or "hybrid" for that gene pair.

When the two genes of a pair are not alike, the character produced may be of an intermediate type; for example a gene producing red pigment with one producing blue might produce a purple colour. On the other hand, the effect of one gene might be completely suppressed. For instance the *blue colour only* might appear in the example I have just taken. In such cases (which are the more usual) the suppressed gene is said to be "recessive" and the other gene "dominant." The segregation of recessives in a homozygous condition provides an explanation for the appearance of "throw-backs."

When, in its turn, the plant comes to form sex cells, a special form of nuclear division occurs in which only *one* member of each chromosome pair and only *one* member of each gene pair enters the resulting daughter nuclei. This provides the basis of the reshuffling of characters in sexual reproduction to which I referred earlier.

In addition to the heritable variation brought about as a result of new gene combinations, other changes sometimes occur in the gene material. These produce effects known as "*Mutations*" and in their more striking form as "sports." Such mutations arise as a result of the spontaneous appearance of new kinds of genes, of new arrangements of genes, or of changes in the number of genes.

The first and last of these may be of use in plant breeding, especially a type of the last class in which *the whole set of chromosomes is doubled in number*. This increase in number of sets of chromosomes is called polyploidy.

To recapitulate, we now have three great generalizations concerning inheritance and inheritable variation. The first, that the hereditary material is almost exclusively divided into discrete particles each with a specific action and transmitted as units from parent to offspring. The second, that these units are borne on visible microscopical bodies known as chromosomes. The third, that heritable variations are almost exclusively due to the appearance of new kinds, of new combinations, or of new arrangements of these units. Finally, I should mention that these generalizations are applicable to almost all organisms, plant or animal, mollusc or man.

Viewed in the light of these generalizations by far the most valuable method of the plant breeder is to make use of gene recombination. The Russians have probably gone furthest in this respect and have established great collections of all the varieties of particular plants that they could acquire. To this end expeditions have been sent out to collect in and about the wild home of the plant in question. So now they have great "reservoirs of genes" to explore and to use in their plant breeding projects. Perhaps their best known collections are those of cottons, wheats, and potatoes.

The work of building new gene combinations is very largely empirical and inevitably must remain so until the available genes are tied up in bags and neatly labelled, a task which almost certainly will never be completed. Its empirical nature is best demonstrated in the case of yield characters. All such characters which have been analysed so far are determined by large numbers of genes each with small effect. Hence the traditional selection

methods, which depend upon the accumulation of these small differences.

Resistance and quality characters in general appear to be dependent upon one or a few genes so that where analysis has revealed the gene or genes involved, the transference of the character from one variety to another may be attempted with almost certainty of success.

After a desirable new type has been isolated the problem of propagation arises. If the new type is pure, or homozygous, it may be propagated from seed without the risk of undesirable individuals appearing among the progeny. On the other hand if the new type is heterozygous it most certainly will produce undesirable "throw-backs." In this case the type may either be propagated vegetatively, forming a clone, or steps may be taken to "fix" the type by inbreeding and the elimination of the harmful recessive characters. Such a fixed type is called a pure line A difficulty arises here, for the value of the new strain may lie in its hybridity. If the strain cannot be clonally reproduced the problem becomes rather more difficult. Two pure parent strains may be produced in some cases from which the precise hybrid constitution may be obtained by crossing. The other alternative is to make the hybrid true-breeding. Although true-breeding hybrids exist in nature and have been produced experimentally, none of agricultural value have yet been evolved. They are produced by inducing a particular form of chromosome abnormality which prevents normal segregation in the germ cells.

In the case of *Hevea*, in spite of the small number of individuals introduced into the East from their wild home in South America, there seems to be a remarkably high degree of heterozygosity among the derived population of seedling trees and hence a large "reserve" of genes to draw upon. Yet, as the number of introduced individuals was so small, it seems certain that many valuable genes must remain among the wild trees of South America.

Nothing is known about the pure genetics of rubber, and for a long time it seems we shall have to proceed along the traditional lines of crossing and selfing plants with obvious good characters, yield and otherwise. In this way we are certain to obtain some better gene combinations and better plants. I have used the word "certain" in respect of the whole of the work, for as yet,

the results of any particular cross or selfing are utterly unpredictable. For instance the buddings of A.V.R.O.S. 36 are weak growing, yet the selfed seedlings of this clone are uniformly strong growers. In the case of A.V.R.O.S. 49 the reverse is true; growth of the buddings is strong and of the selfed seedlings weak.

Now I will proceed to another method used by the plant breeder: interspecific hybridization. This is used when a character occurs in one species which would be of value in another closely allied species of economic importance. The transference of such characters may be greatly complicated by the occurrence of hybrid sterility, or again by gene interaction, which prevents the expression of the gene except in the presence of the correct constellation of other genes. However some valuable results have been obtained, particularly in the field of disease resistance characters. Interspecific hybridization may also be of value when it is required to obtain a plant combining the characters of two distinct species. The most striking example of this has been the production of a perennial wheat by crossing various wheat races with the perennial couch grass. I will not attempt to explain how this occurs beyond pointing out that the process involves the doubling of chromosomes in the hybrid. Moreover, it is not to be confused with the method to which I have just referred whereby a true breeding hybrid is obtained *within* the species.

The possible value of interspecific hybridization in rubber cannot be assessed as yet. In this connection I would draw your attention to the hybrids between *H. Brasiliensis* and *H. Spruceana* mentioned by Mr. Murray this morning which are being used in a stock experiment in Sumatra.

Finally, I would refer to the value of polyploidy, or increasing the number of chromosome sets (usually from two to four).

The value of polyploids lies very largely in the increased cell size and more robust habit of such plants. In this way greater yields may be obtained. However, qualitative changes of value may also be induced. A good example of both is the polyploid tomato which is not only a stronger plant, producing bigger fruit, but also has a higher vitamin C content than the normal diploid.

A large majority of our cultivated plants are polyploids, or have polyploid strains. The induction of polyploidy in Rubber may possibly be of value, particularly in view of the fact that cell size is thereby increased, for yield is at least partly dependent upon latex vessel size. That completes my brief review of the methods of plant breeding and the principles upon which they are based.

In conclusion, it might be useful if I summarised the lines on which *Hevea* breeding is progressing and the stage which has now been reached. There is firstly the selection of clone mother trees from the normal seedling population. Next there comes the crossing or selfing of the clones derived in this way. At this point it must be stressed that the seedling progeny obtained from these pollinations is extremely variable both in yield and other characters. This is presumably due to the marked heterozygosity of the parents. The next stage is to select the best among this seedling progeny and test them for their suitability as clone mother trees. In their turn these second generation clones would be selfed, crossed among themselves, or back crossed to the parents. Again there would follow the selection of the best among the progeny, and so the process would continue. I would stress another point, namely, that until by these or other means a high yielding pure line is obtained, the best legitimate or illegitimate seedling population *must* lag behind the best clone as far as yield potentiality is concerned. The crossing of selected *Hevea* trees in this way was commenced by Heusser in Sumatra prior to 1920. In that country and in Malaya there are now some young seedling trees of which all four grand parents are known. Of first generation hybrid seedlings some are outstandingly high yielders. The clone A.V.R.O.S. 255 which is now strongly recommended for planting in Sumatra, has been derived from one such seedling.

As an indication of the information obtained as a result of this early work it may be mentioned that the clones A.V.R.O.S. 157 and Pilmoor A 44 both give high yielding progenies when used as parents in legitimate crosses. In other words they both seem to contain dominant characters for high yield. (Though both appear to be associated with certain undesirable secondary characters).

It will be evident from this that the breeding work with *Hevea* has only just commenced. It would seem to have a very promising future.

DISCUSSION

Mr. A. H. Healey referred to the fact that in any frequency graph of Rubber showing the number of trees in each grade of yield, it is found that the numbers in the under-average grades are increased. He enquired whether such a skew-shaped graph was the unavoidable result of the hereditary factors brought into each plant at the moment of birth or whether it might be attributed to the effects of subsequent treatment by the planter, such as tapping, erosion of the soil or overcrowding.

Dr. Ford replied that both environmental and hereditary factors would be involved in the shaping of the curve and that the planter could not be held responsible.

Mr. O'Brien enquired whether, in the case of a seedling derived from two known parents, it would be possible by microscopic examination of the cell nuclei to say whether any particular characteristics had been inherited.

Dr. Ford said the answer was definitely in the negative.

RUBBER NURSERIES

G. BRUCE FOOTE

(ELSTON ESTATE)

I have been kindly invited to say a few words today on nurseries and how to prepare them. I do not presume to think that I know more about this subject than many here present or that my methods are necessarily the only correct ones, or that they are particularly cheap, but I do lay claim to their being successful and I consider it essential to give the young plants the best possible start.

I trust that a short account of my methods and experiences will bring about a frank discussion from which we may all learn something.

SITE

For the benefit of any uninitiated who may be present I would mention it is advisable, on steep and hilly estates, to choose a damp hollow, close to a small stream as such is the most likely place to find a suitably flat area, and water should be handy in case of drought, also in such a locality there will probably be a good depth of alluvial soil fairly free from rock and stone.

The land should not be swampy as this will necessitate heavy drainage; any water logging will be fatal to the young plants. Care must also be taken that the land is not subject to sudden floods, as I found to my bitter cost.

I thought I had given due consideration to this aspect, and chose two sites, that, to my personal knowledge, over a period of 10 years, had not been inundated, but within three months of planting up two nurseries, a cloudburst carried away a large portion of one and severely damaged the other.

On this occasion some 5 inches fell in a little over $1\frac{1}{2}$ hours. I mention this to show how careful one must be.

PREPARATION

Having cleared the land of all trees or jungle before laying out the beds, it is necessary to fork over the land as deeply as possible to remove all roots and stones.

It should be possible to push a walking stick easily to a depth of $2\frac{1}{2}$ to 3 feet into a well prepared bed. The benefit of this will be seen when it comes to pulling the budded stumps for planting.

If the sub-soil is stony the taproots will be distorted instead of straight and, even if not broken off short in pulling, they will most probably have all the tender bark flayed off their lower extremities.

It will seldom be found that there is sufficient flat land to lay out beds for a nursery of 15 to 20,000 plants without having recourse to terraces; it is essential that beds be absolutely flat to prevent wash.

Terraces should be as shallow as possible and beds may have to be restricted to some 5 feet 6 inches in width, narrower beds should be avoided if possible.

It is advisable to turf the edges of the terraces to prevent erosion: the grass must be kept weeded back carefully for the first few months but the young plants will soon close over the space between beds and the grass will die out, but by this time the overshading foliage and litter of falling leaves will stop erosion to a great extent.

Drains between beds should be quite shallow, not more than 3 inches to 4 inches deep and 9 inches to 12 inches wide. If the land is very flat beds may be $11\frac{1}{2}$ to $17\frac{1}{2}$ feet wide: but these will very seldom be obtained.

DRAINS

In every site chosen it will usually be found that there are old leader drains or natural depressions which it is advisable to convert to such, to carry off surface water to the main stream; these drains should be cut to a sufficient depth to ensure that the nursery is well drained and not water logged.

If necessary the banks of these drains should be turfed and strengthened with young saplings, driven into the bottom of the drain at an angle to prevent the banks caving in.

FENCING

As nurseries are, as a rule, not needed for more than 2 to 3 years it is not necessary to go to the expense of concrete posts, good jungle posts should suffice, and as the area of ground is small the fence can constantly be under supervision.

If, however, it is intended to maintain the site as a nursery for a longer period it may be advisable to put in concrete posts.

At least 4 strands of barbed wire should be fixed to the posts, and 4½ feet of ¾-inch wire mesh fixed all round to the barbed wire: 3½ feet above ground and 1 foot underground to keep out hares and other rodents, stray chickens, etc.

I attribute my almost complete freedom from bandicoots to the fact that the wire mesh was so buried. Suitable stiles or locked gates must be provided to allow of ingress and egress.

GERMINATION

One or two small beds should be set aside for germination: cover these with 2-inch layer of clean sand: seed may be laid on this touching one another, care being taken to lay the "Stripe" downwards, and then covered with a further ½-inch layer of sand.

The whole should be shaded with a pandal of ferns, and the beds lightly watered morning and evening in dry weather. Good seed should germinate in about 8 to 10 days, though some may take longer.

As soon as the first shoots appear above the sand the seed should be carefully picked over and all germinated seed removed to the nursery proper, care being taken to see that the roots and stems are coming away cleanly: any twisted plants should be discarded: the ungerminated seed should be put back in the germination beds, and the process repeated until the required number of plants are put out in the nursery.

Normally speaking one should be safe to allow for 75 per cent germination from good fresh seed, but it is advisable to allow a further 10 per cent for supplies in the nursery proper as some plants may die or be eaten by pests, but it is not much use supplying after the first 10 days as the plants will be backward, and become overshadowed and whippy: a few rather large plants might be kept for this purpose and if watered well should come on and be even with the first planting.

If there has been much Phytophthora about it may be wise to allow for only 50 per cent of seed germination.

It is I think better to arrange to germinate your seed in 3 or 4 batches, instead of collecting all at one time.

PLANTING

After deciding the distance of planting the germinated seed should be carefully planted out: covered to about $\frac{3}{4}$ of an inch, and then lightly shaded with bracken for a few days.

If the weather turns at all dry the nursery should be watered, half in the morning and half in the evening.

Do not water after 8.30 a.m. or before 3.30 p.m. as the sun is too hot. Use a medium rose watering can so as not to wash the soil off the seed and tender rootlets, as the young plants continue to draw nourishment from the seed for some time after they are put out.

I have tried several different spacings for seedlings, and finally arrived at the following: two rows one foot apart, a gap of two feet, and a further two rows 1 foot apart; plants spaced at 9 inches apart in the rows, leaving 9-inch margins round the beds.

This works out at approximately 38,000 plants per acre, but allowing for drains, paths, etc., it will be considerably less, and one would probably require rather over an acre of land to accommodate 30,000 plants.

Were I making another nursery I would increase the spacing in the rows to 1 foot. I do not consider this would entail making a larger nursery as there would be so many less whippy plants that one could allow for planting out a smaller number originally, and thereby utilise the space to its best advantage.

MAINTENANCE

This consists of monthly weeding, which does not amount to much after the first few months, attention to fences, and resurfacing the beds if rain has caused root exposure.

Watering may have to be done for the first month or so should a dry spell be experienced.

PESTS

The first pest to appear will probably be squirrels. In one nursery, surrounded by jungle, I had to employ a watchman all day to shoot them as they caused so much damage by pulling

up the germinating seed. Lizards will also cause some damage by bitting off the tops of young plants, but my experience is that it does not amount to very much, and the small boys employed to drive off or kill them did quite as much damage.

Bandicoots I have heard of as doing damage, but I, luckily, have only lost a dozen or less plants from these pests, and poison will very effectively banish them.

Cockchafer grubs can do an immense amount of harm, but luckily I have experienced none in my nurseries, though I have had thousands in the clearings.

I have been told that carbon bisulphide applied to the soil will destroy them, but this chemical is very expensive, poisonous, inflammable, and only obtainable in small quantities in Colombo, so the treatment does not appear to be very practicable.

I have also been informed that these pests may be successfully trapped by burying an ordinary turf sod 9 inches × 6 inches upside down just flush with the level of the bed: this sod can be taken up from time to time and young cockchafer grubs removed and destroyed.

Slugs and snails have avoided me: they can easily be exterminated with Meta fuel.

Fomes, and, I dare say, other root diseases can be very troublesome, but luckily I have escaped these altogether: they would have to be treated on the usual lines adopted for young clearings, and I can do no better than refer you to "Diseases and Pests of the Rubber Tree."—Sharples.

Oidium may cause trouble but here again I have luckily escaped damage in spite of severe attack in the old rubber: this is probably due to three of my nurseries being situated in jungle, the fourth was probably too young to suffer this year.

The one disease which has caused me much concern has been Bird's Eye Spot (*Helminthosporium Hevea*).

This leaf has appeared in all four nurseries, and has caused very severe damage to the foliage for a short period. At first I became very alarmed and feared I would never be able to get the nurseries ready for budding within a year.

The disease appeared to attack the young plants when they are about 2½ to 3 feet high; the familiar spots appeared on the leaves and either caused malformation or wilting, and

eventual defoliation of the terminals, and growth was badly checked.

I would here take the opportunity of thanking the various officers of the Rubber Research Scheme, and the Department of Agriculture who so kindly examined my nurseries and gave me much advice. But either I was too dense to apply the advice properly, or the advice was, *ab initio*, of no use.

When the attack first started I tried sulphur dusting without success. I subsequently expended large sums on buying sprayers and sprays: I tried Bordeaux mixture, Bouisol, etc., with little or no good result, and was eventually forced to the conclusion that they were a waste of money.

After a time I tried a large dose of manure and found that it worked splendidly, for as soon as as the plants were forced up to a height of six feet or so the disease, though always present, became so mild as to be negligible.

MANURES

I have experimented with several mixtures including animal meal, and, as I was manuring with sulphate of ammonia alone in the old Rubber at the time, I took a little of that, and applied it to a few beds at the rate of ½ oz. a plant when the young plants were pencil thick.

Whatever effect sulphate of ammonia alone may have on old Rubber it is useless for young plants, these beds lagged behind sadly. The mixture I have found by far the most satisfactory is:—

225 lbs.	Nitrate of Soda
75 lbs.	Basic Slag
50 lbs.	Bone Meal
50 lbs.	Muriate of Potash
400 lbs.	

Nitrogen	Phos. Acid	Potash
36.37	25.25	25.00

I was led to choose this mixture as I required a very quick acting manure to boost up the plants against Bird's Eye Spot, and nitrate of soda is the most readily available form of nitrogen but it has the property of deflocculating clay soils, and the bottom end of my nursery already tended to be sticky, so basic slag was introduced for its free lime, and flocculating properties, to counteract the soda.

Bone meal was introduced merely as a conditioner, and muriate of potash as a quick and cheap source of potash. Anyway the manure reacted exceedingly well, and it is now my standard nursery mixture.

Owing to trouble with Bird's Eye Spot, I have probably manured my nurseries rather extravagantly, and more than would be necessary in a normal nursery unaffected with leaf disease.

After many experiments I have arrived at the following dosage: 3 months after planting, when plants are pencil thick, 1 oz. of mixture per plant, if the weather is wet, or 1 oz. of animal meal if weather is dry: the manure mixed with 3 times the amount of dry earth: 3 months later 1 oz. of mixture per plant. 3 months later ½ oz. mixture per plant to good beds 1 oz. to backward beds—costing approximately Rs. 90 for a nursery of 10,000 plants.

It is not advisable to manure later than the 8th or 9th month as the application of manure at or near the time of budding is supposed to have some ill-effects on the percentage of budding successes.

It is preferable to bud a nursery in dry weather as the ground under the dense shade is usually damp enough, and it is easy to water in the early morning if the soil is dust dry. In showery weather much time is wasted waiting for stems and leaves to dry.

If there is any water on the leaves it may easily be disturbed and drop on the bud patch while the cooly is budding.

COSTS

It is a little difficult to speak about these as people have various methods of grouping their costs, and they must vary considerably according to individual conditions.

My own method has been to charge everything including the cost of a small amount of imported budwood, and making of two small budwood nurseries, the rebudding of an old budwood nursery, and budding all the plants in the main nursery to "Nursery Account" and then purchasing my budded stumps from "Nursery Account" at the time of planting out.

My costs have, I think, been rather high, as I experienced three large slices of bad luck, all of which proved costly. I have already referred to an unprecedented cloudburst which

did severe damage to two nurseries, necessitating abandoning part of one, and opening an extra nursery.

Two of my nurseries were opened in jungle as no other site was available. The clearing of the jungle was somewhat expensive, and when I had almost completed this I came across two old jungle stumps infected with what looked suspiciously like Fomes, and, rather than risk future disasters, I abandoned a large part of the site and opened another.

I have already alluded to serve attacks of Bird's Eye Spot, which affected all four nurseries. All these circumstances greatly enhanced my costs.

I estimate that when the whole of my planting programme has been completed and supplies put out that each plant will stand me in at 18-19 cents. Normally they would not cost more than 14-15 cents or less.

I would also mention that it is advisable when laying down a nursery to allow a fairly liberal margin for whippy plants and plants which will fail to bud.

I would recommend anyone to allow at least 50 per cent to be on the safe side. This will, however, probably mean that they will be somewhat overstocked.

I find myself accumulating a large number of surplus budded plants, which I hope to sell. Should I succeed it will very materially reduce the cost of my plants.

The figures I have quoted include the purchase of only a small amount of special budwood as luckily I had the foresight to lay down a small budwood nursery as far back as 1930; and I have been able to supply almost all my requirements from that.

BUDWOOD NURSERY

A small budwood nursery can be easily, and inexpensively, made at one end of what will be the main nursery, by removing roots and cutting holes 2 feet × 2 feet × 3 feet spaced 3 feet × 3 feet.

These should be filled with good soil and planted with 2 or 3 seed in each hole: the plants budded when of a suitable size. This plot need not be forked so deeply as the main nursery.

If more than one bud takes plants can be uprooted and used to extend the nursery. The cost will depend almost entirely on the prices paid for budwood.

These are all the points that I can think of but there are no doubt many others which will I hope be discussed.

DISCUSSION

Mr. R. K. S. Murray enquired why the "standard nursery mixture" was used for the first application when the weather was wet and animal meal when the weather was dry. He would have expected the reverse to be preferable.

Mr. Foote replied that he feared a burning effect from the mixture in dry weather.

Mr. W. R. Thomson expressed the opinion that stickiness produced by the continuous use of nitrate of soda could not be corrected by the use of alkaline manures such as basic slag.

Referring to the use of the chemical type of mixture as opposed to the organic he pointed out that one of the principal objects in using the latter was to avoid a dangerously high concentration of salts where manuring was necessarily at a very high rate per acre.

Mr. Foote said that details of his mixture had been submitted to an expert whose only criticism was that the mixture was exceedingly powerful. He had replied that he was looking for dynamite.

Mr. E. W. Whitelaw said he thought the costs quoted by Mr. Foote were far too high even after making allowance for extra expenditure referred to in the paper. In his experience the cost should be about 8 cents per stump, exclusive of the cost of budwood.

THE SMALLHOLDINGS DEPARTMENT OF THE RUBBER RESEARCH SCHEME

W. I. PIERIS

SMALLHOLDINGS PROPAGANDA OFFICER

(RUBBER RESEARCH SCHEME)

ORIGIN AND OBJECT

THE Smallholdings Department of the Rubber Research Scheme (Ceylon), owes its existence to a realisation on the part of the Board of Management of the Rubber Research Scheme in recent years, that there was, in Ceylon, no proper organisation for giving advice and assistance to Rubber smallholders in the various matters connected with the cultivation, management and preparation of rubber. Especially was this so in the case of smallholders who could not read and write English. The advice and help of the Rubber Research Scheme, though meant, in theory, to be available to all classes of Rubber owners, actually, in practice, had no proper means of reaching those owners who were unprogressive, illiterate, or illiterate in English. Considering that 254,412 acres out of a total of 604,068 acres or 42 per cent of the total Rubber acreage in Ceylon consist of small estates and holdings of under 100 acres and that all rubber producers, including the smallest smallholder, contribute to the cess of $\frac{1}{8}$ per cent (on a lb. of rubber exported) by which the Rubber Research Scheme is maintained, I think it will not be difficult to appreciate the motives which actuated the formation, by the Board, of the Smallholdings Department. If further justification is necessary, I need only refer to the generally poor condition of, and the backward and ignorant methods prevailing on, the average Rubber smallholding in Ceylon which are well known to most planters.

SCOPE AND ORGANISATION

As a preliminary step to the organisation of the Smallholdings Department, I, as officer-designate to be "Smallholdings Propaganda Officer" in charge of the Department, paid a two months' visit to Malaya in October 1935 to study the

"Smallholders Advisory Service" of the Rubber Research Institute of Malaya, which was an organisation doing similar work in Malaya to what we intended to do in Ceylon. I have to express my indebtedness to the Director and Board of Management of the Rubber Research Scheme for the opportunity of this visit, which has been of considerable value in my subsequent work in Ceylon.

Actual smallholdings work in Ceylon, however, was only commenced in November, 1936, when two "Rubber Instructors," after necessary training, were stationed in charge of the Matugama and Horana Ranges respectively under my supervision. After a review of the work done and being done by the Department, the Board decided at the end of 1937 to increase the number of Rubber Instructors to a total of six, and consequently, during the period April to June, 1938, four extra Instructors were stationed at Galle, Ratnapura, Ruanwella and Katugastota. The Department, therefore, consists, at present, of a Smallholdings Propaganda Officer and 6 Rubber Instructors in charge of 6 ranges which cover the main Rubber districts of Ceylon. An additional junior staff officer, under the designation of "Clerk and Translator," attends to the clerical and other work in the office and translates the Department's publications into Sinhalese.

Special attention is paid to the selection and training of Rubber Instructors who are required to have passed the 8th. Standard in Sinhalese, the Junior Cambridge in English and preferably also to possess the Diploma of the Farm School, Peradeniya, or other suitable agricultural experience. After selection, they are given a special course of training lasting about 3 months under the Rubber Research Scheme, before being assigned to their respective ranges. This consists of a course of lectures by me covering subjects in which they are required to give instruction to smallholders, followed by periods of practical training in budding, tapping, sheetmaking and general field work at Nivitigalakele and Dartonfield. The training is rounded off by a few days spent with one of the original Instructors, seeing the actual demonstrational and instructional work done in a range. At the conclusion of the training, they are set a test paper on the instruction they have received and also given a practical test in budding. On being assigned to his range, each Instructor is supplied with an official "identification card," which certifies his official capacity.

The scope of the activities of the Smallholdings Department is confined to estates and holdings not exceeding 30 acres in extent.

FUNCTIONS

An Instructor's duty on being assigned to his range, is to communicate to smallholders what has already been taught him and to give them general advice and assistance regarding their individual Rubber problems. This he does in various ways, but mainly by means of visits to holdings, practical demonstrations to groups of small owners, and free distribution of leaflets published by the Department. All recommendations made, both oral and written, are simplified as far as possible to suit the understanding and pockets of the average smallholder.

Demonstrations form one of the principal and most useful means of propaganda employed. With the assistance of the minor headmen, whose co-operation is arranged for through the head of the department, groups of smallholders are assembled at an appointed time and place and demonstrations in particular subjects given by the Instructor. Demonstrations are given in sheetmaking, budding, marketing and tapping, disease treatment, compost making, prevention of soil erosion, etc. In sheetmaking for instance the process of making a decent sheet is explained and demonstrated step by step from the bringing in of the latex to the removal of the rolled and washed coagulum into the smokehouse. It is explained that by following instructions and producing a clean sheet, a smallholder can get at least half cent more on a lb. of his sheet, which will well repay his extra trouble. Each Instructor carries a set of utensils and tools necessary for demonstrations.

Instructors also render practical assistance to smallholders by contour-lining holdings with the road-tracer for draining and holing in connection with replanting, assisting in budding holdings and nurseries so far as other duties permit, helping to procure planting material from reliable sources, filling applications for permission to replant, improving and putting up smokehouses and in a number of other ways.

The Department has also opened up in each range (in the new ranges this work is still progressing) small replanted blocks, smokehouses and seedling nurseries for purposes of demonstration and instruction. The replanted blocks, about ½ acre in extent each and at present one in each range, usually adjoin the

main road and, besides demonstrating how replanting might be done by small proprietors, have helped to work out costs of replanting under actual smallholding conditions. Smallholders are directed to their local Instructor for particulars by the erection of a notice board in Sinhalese opposite each block. The demonstration smokehouses, 4 or 5 in each range, are modelled on plans specially prepared by the Smallholdings Department for smallholders. There are two types of houses recommended, one with a capacity of 80 sheets and costing Rs. 15, and another for the very poorest type of smallholder with a capacity of 12 sheets and costing only Rs. 8-50. Both houses are built of wattle and daub. They embody in a simple way the essential principles required for proper rendering and, in actual practice, render a very satisfactory sheet. The Rs. 15 house is capable of dealing with the crop from a 15 acre holding. The seedling nurseries, 4 to 6 in each range, provide stocks for giving demonstrations and instruction in budgrafting to small owners.

A not unimportant function of the Smallholdings Department is the publication and isuse of free leaflets both in English and Sinhalese. The recommendations made in these leaflets are specially adapted to suit smallholders and they are written and translated in simple language. Up to the present leaflets have been issued on "Replanting of Rubber" and "the Preparation of Smoked Rubber Sheet." An existing leaflet on "Budgrafting" has also been translated and issued in Sinhalese. In view of the fact that very little similar Rubber literature in Sinhalese has been previously available, it is felt that these publications are serving a useful and necessary purpose.

To encourage smallholders to improve the general condition of holdings and the methods practised, competitions are held annually in each range and prizes given. Two such competitions in the Horana Range, one for the "Best Kept Holding" and another for the "Best Smoked Sheet" have just reached the stage for judging.

The vogue in recent years for replanting with high-yielding budded material has not altogether failed to interest the smallholder and the Department has sold, during the past two years, quantities of budwood and budded stumps to small owners. As the issue of material by the Rubber Research Scheme next year has been solely restricted to smallholders more work in this direction is anticipated.

An enquiry into the marketing conditions of smallholders' sheet might be mentioned as an example of the type of investigation sometimes undertaken by the Department. It was found that the provincial rubber dealer, apart from reaping unfair profits at times, seldom or never buys the smallholders' sheet on a graded basis according to quality, so that there is no inducement for the latter to make a better sheet. An organised system of purchase by grading, therefore, would be a definite step in improving the quality of smallholders' rubber. A scheme was suggested for trial whereby dealers should put up "rubber price boards" showing the prices they were prepared to pay for different samples of sheet on the day's market price. They were reluctant to try this, however, saying that unless all dealers adopted the scheme, those who attempted it might lose business. Consequently other means of dealing with the problem have been discussed with the Commissioner for Agricultural Marketing and are under consideration.

I might, in conclusion, say that there are other aspects of the Department's work which it is not within the scope of a short paper like this to cover fully. I owe a debt of gratitude to those who gave me this opportunity of telling you something about our work, and I hope I have been able, even in a small way, to interest you in a subject about which, perhaps, some at least of you had not heard very much before.

DISCUSSION

Asked what the response from the smallholders was to the efforts of the department, Mr. Pieris said that owing to the low price of uncouponed rubber, improvement of manufacture and erection of smokehouses by smallholders had not progressed to the extent they had expected. Several smokehouses had, however, been put up, based on the design of the demonstration houses. A good deal of interest was being taken in the question of replanting with improved material.

Mr. G. S. Ross asked whether it was usually found that smallholders sold their coupons and then their rubber afterwards.

Mr. Pieris replied that when the smallholder took couponed rubber for sale, the dealer bought the coupons and the rubber separately. Usually the coupons were sold in advance.

Mr. O'Brien appealed to planters to support the work of the department by encouraging smallholders in the vicinity of their estates to make use of the services of the instructors.

OIDIUM LEAF DISEASE

R. K. S. MURRAY,

BOTANIST & MYCOLOGIST.

(RUBBER RESEARCH SCHEME)

MY presence on the platform for the second time today calls for an explanation. The Conference Committee felt that, in view of the interest which has been aroused in Oidium during the course of the year, it was important that this subject should be included on the Conference Agenda.

The Committee hoped that as Matale is the district most concerned one of the Estate Superintendents from that district would be good enough to give us the benefit of his views and experience in the form of a paper. I understand that this has unfortunately not proved possible, and I have therefore been asked to read a short statement summarising the work which has already been carried out by the Research Scheme on the control of this disease, and formulating proposals for further research. This statement was recently prepared for the Rubber Research Board.

SUMMARY OF WORK CARRIED OUT BY THE RESEARCH SCHEME ON OIDIUM CONTROL

The services rendered by the Rubber Research Scheme to the industry in connction with Oidium leaf disease may be considered under two headings:—

A. Experimental.

B. Demonstrational and Advisory.

A. EXPERIMENTAL

In the control of a fungus disease there are always three possible lines of work: (1) direct control by killing the causative fungus, (2) indirect control by cultivation methods, (3) selection or breeding of immune or resistant strains, and the following statement indicates briefly the work that has been conducted along each of these lines and the results achieved,

1. DIRECT CONTROL BY KILLING THE CAUSATIVE FUNGUS

The first experiments were carried out in 1929 with liquid spraying with a proprietary sulphur fungicide. The results were inconclusive, and this troublesome and expensive method was abandoned as soon as a satisfactory technique for dry dusting was evolved.

The first trials of sulphur dusting were made in 1930 on two estates in Matale and one in Uva. The results were very promising and it was concluded that with improvements in the technique the treatment would prove to be a practicable estate measure. One of the areas treated was a field of 30 acres on Kandanuwara estate, Matale, at an elevation of about 2,000 ft., and this field was dusted under the joint supervision of the Estate Superintendent and the Research Scheme for six successive years, from 1930 to 1935 inclusive. During this time yield records were kept in the dusted area and also in an adjoining untreated field. When this work was discontinued at the end of 1935 the following conclusions were drawn:—

1. That satisfactory, though not complete, control of the disease can be obtained at this elevation (2,000 ft.) provided abnormal rains are not experienced during the refolaition season, and that while a reasonable foliage is present the yield and rate of bark renewal are maintained at a normal level.

2. That in the absence of any control measures the yield of severely affected areas eventually falls to a totally uneconomic level and the trees become practically untappable.

Results obtained on estates have confirmed the conclusion that in normal season sulphur dusting is a practicable, effective and reasonably inexpensive method of control provided adequate supervision is exercised.

During the development of the sulphur dusting method advice was given to manufacturers on the construction of suitable machines and a number of machines and proprietary brands of sulphur were tested in the field or laboratory. A type of sulphur bomb for the treatment of individual trees or small areas was also evolved in conjunction with a firm of fireworks manufacturers.

2. INDIRECT CONTROL BY CULTIVATION METHODS

In 1929 an experiment was commenced to study the value of manuring in a severely affected field at an elevation of 2,000

feet, particular attention being paid to the possible nitrogen and potash effects. The results of two successive annual applications of various fertilisers were entirely negative, and it was concluded that in severely affected areas manuring alone was of no value. Observations on a number of estates confirm the fact that manuring has no direct effect on the incidence of the disease though it may help the trees to recover, particularly on low-country estates where defoliation is less extensive.

3. SELECTION OR BREEDING OF IMMUNE OR RESISTANT STRAINS

Work on these lines has been confined to observations in 1929 and 1930 of the foliage of over 1,000 individual trees on Kandanuwara estate. No evidence of true varietal resistance was found, the only type of immunity being the consequence of wintering abnormally early when the fungus was inactive.

B. DEMONSTRATIONAL AND ADVISORY

Having developed what was considered to be a satisfactory method of control attention was given to what may be termed "extension service." This consisted of a series of lectures and demonstrations to Planters' Associations, the preparation of advisory literature and advice and assistance to individual estates. As an indication of the volume of this work the following figures for 1934 and 1935, the years in which advisory services on this subject were most in demand, are given:—

Lectures and Demonstrations ...	10
Published Papers	4
Visits to Estates	51
Enquiries	314

These figures refer only to the subject of Oidium

Under the heading "demonstrational" may be included the sulphur dusting by the Smallholdings Propaganda Officer of five smallholdings in the Central Province in 1935 and approximately 1,000 acres of small estates and holdings in 1936. The report on this work is included in Bulletin No. 53.

To sum up, the Research Scheme can claim that in sulphur dusting it has developed a form of treatment which keeps Oidium sufficiently under subjection to arrest or at least greatly to retard the rate of deterioration of trees planted at relatively high elevations. The operations have been shown to be practicable as an

estate measure and reasonably inexpensive. Advice and assistance in carrying out the treatment has been given to all classes of producer.

That the treatment does not achieve complete control may be attributed to the following factors:—

(1). At relatively high elevations the meteorological conditions are very favourable for the development of the fungus and less favourable for the host.

(2). In certain years wet weather prevails during the period of refoliation, which not only washes much of the sulphur from the leaves but probably also reduces the fungicidal efficiency of such sulphur as remains.

(3). The practical difficulties of applying a fungicide to the foliage of tall trees grown on hilly land render a complete covering of all leaf surfaces impossible of achievement.

With the possible exception of increasing the adhesion of the sulphur to the leaves these difficulties are considered to be insuperable. Sulphur is universally recognised as the most effective fungicide for this type of disease, and the chances of evolving an alternative method of *direct* control which could compare in efficiency and economy with sulphur dusting are very remote.

PROPOSALS FOR FURTHER RESEARCH

The poor results obtained with sulphur dusting in 1938 as a consequence of unseasonable wet weather have focussed attention on the problem of the control of Oidium, and the possibilities on the one hand of exploring alternative methods of control and on the other of improving the efficiency of the existing treatment merit careful consideration. The lines along which further research might prove profitable are:—

(1). Discovery or evolution of high yielding strains resistant to the disease by selection and/or breeding.

(2). Field trials of various brands of dusting sulphur.

(3). Tests, in the first place on a laboratory scale, of various substances as adhesives.

This subject is being brought to the attention of the Board in order to ascertain the views of members regarding the desirability of working on these or any other lines that might be suggested. The scope of such work is indicated below.

(1). Preliminary investigations carried out in 1929 and 1930 with a view to discovering resistant trees were not very encouraging. As the result of the inspection of over 1,000 individual trees on a very severely affected estate, and more general observations extending over a considerable area, no evidence of varietal resistance was found. It is usually possible in even the worst areas to find a small proportion of trees with healthy foliage, but in my experience these have always escaped attack on account of having wintered "out of season" at a time when the fungus is inactive. This type of immunity is considered to be of no value, for if trees having this habit were planted in mass the fungus would soon adjust itself to the changed seasonal conditions. Ever since these preliminary investigations were made the Staff of the Research Scheme has been depleted and it has been impossible to pursue the matter further. Now, however, that a Geneticist has assumed duties the whole subject of tackling Oidium by selection and breeding methods can receive renewed consideration.

The success of such work would be largely dependent on the co-operation of Estate Superintendents in severely affected mid-country areas, and the first step would be to endeavour to secure such co-operation in, say, the Matale district. Superintendents would be asked to mark any individual trees whose foliage was conspicuously healthier than that of their neighbours, and these trees would come under the special observation of an officer of the Scheme during the period of refoliation. From any such trees which also give a high yield clones would immediately be established, if possible on the estate itself. Any trees with a high degree of resistance (if such be found) but low or moderate yield would be crossed with known high yielding clones in the hope that a proportion of the progeny would develop both high yield and resistance. From such plants clones would be established.

It need hardly be stressed that this work cannot be expected to produce results of value for many years. It is, indeed, doubtful whether any useful degree of immunity from Oidium exists.

Reports that certain of the well established clones remain relatively free from Oidium are current, and this matter will be investigated.

(2). From time to time certain brands of dusting sulphur which are new to Ceylon are brought to our notice. Claims are

usually made by the manufacturers or prospective selling agents that these products have advantages over the brands in current use, either by reason of greater efficiency or lower price. A laboratory examination is often sufficient to condemn these dusts, but in some cases they appear to be worthy of a field trial. Such a trial can only be carried out satisfactorily on a large scale in an area where the incidence of the disease is high. One or two products are awaiting such a trial at the present time, and it is suggested that experiments be carried out during the 1939 season if the co-operation of one or more estates can be obtained. These experiments would be carried out on the same lines as in 1935 except that we would not anticipate any financial implications.

(3). Certain products have been suggested as adhesives for mixing with fungicidal dusts, and although no great success seems to have been obtained by other workers they might be subjected to a laboratory trial. The main problem in such work would be to evolve a satisfactory technique for testing adhesion to young leaves. The advice of the Imperial Mycological Bureau might be helpful.

DISCUSSION

Mr. D. C. Gordon-Duff enquired whether a more finely divided sulphur could not be used.

Mr. Murray replied that there were some products on the market which were even finer than those in common use but that their cost was almost prohibitive.

Mr. E. W. Whitelaw enquired about the effect of sulphur dusting areas at an elevation of over 1,500 feet. He was of the opinion that Rubber at such elevations was dying though the Rubber Research Scheme would not admit it.

Mr. Murray replied that he thought Mr. Whitelaw had misinterpreted the views of the Research Scheme. They admitted that eventually such areas would probably become uneconomic, but they had to take the view of the proprietors of such Rubber and make the best of a bad job. The experiments on Kandanuwara estate had shown that the deterioration could be greatly arrested by sulphur dusting, though whether this was an economic proposition at present prices was uncertain and would have to be decided for each case on its own merits. He was glad that he did not have the responsibility of making the decision.

Mr. Atkinson said that he had dusted Rubber at an elevation of 1,600 feet for 4 successive years. In the first two years the results were good but in the last two the results were disappointing. "It seems to me," he said, "that the trouble is to control this wretched weather."

Mr. Murray remarked that he hoped Mr. Atkinson did not suggest that the Research Scheme should form a meteorological department.

Mr. G. S. Ross asked what effect sulphur had on Tea.

Mr. Murray replied that experiments carried out by the Tea Research Institute showed that sulphur caused a taint of tea if it fell on the bushes in sufficient quantity. His advice was that when dusting a field of Rubber adjoining Tea great care should be taken that the margin should be treated only when the wind was blowing away from the Tea into the Rubber. If this was impossible a belt 50 yards wide might have to be left untreated along the boundary. Arrangements should be made to dust as soon as possible after the Tea had been plucked.

Mr. Foote said that he had sulphur dusted on the boundary of an adjoining tea estate a day or two after plucking and had received no complaints.

In reply to an enquiry whether any work on breeding clones resistant to Oidium had been carried out in other countries, Mr. Murray said that he knew of no such investigations.

In reply to another enquiry, Mr. Murray said that trees could be attacked by Oidium at all ages but that defoliation was usually less severe on young trees which were growing vigorously.

Mr. A. T. Sydney Smith asked whether Mr. Murray thought that Oidium would become more severe in the lower districts.

Mr. Murray said that he thought he could most discreetly reply by saying that his academic qualifications did not fit him to assume the mantle of a major prophet.

DISCUSSION ON REPLANTING PROBLEMS.

Mr. E. W. Whitelaw initiated a series of short discussions on various problems of a controversial nature connected with replanting.

BUDDING IN THE FIELD OR THE NURSERY

Mr. Whitelaw said that until recently he was an advocate of budding in the nursery and transplanting to the field, but now he thought that in the long run better results would be obtained by budding in the field. The transplanting operation involved a loss of at least 15 to 20 per cent plants, the early growth was not so rapid, and the supplying of vacancies meant an uneven growth as compared with the results of successful budding in the field, especially when 2 or 3 good seedlings per hole were available.

Mr. Gordon-Duff said that there were certain areas where budding in the field did not seem to be so successful.

Asked for his opinion, Mr. P. R. May said that the success of transplanting was largely dependent upon the weather. He had recently seen an area budded in the field where duplicate plants transferred from one hole to another had actually made better growth than those left to grow undisturbed but also quoted a case of 40 per cent failure when drought immediately followed the transplanting of nursery buddings.

Mr. Foote said that 15 to 20 per cent was too high a figure for casualties.

Mr. Murray stressed the need for care in the operation of uprooting stumps from the nursery and transplanting them. Although weather was an important factor the number of losses could be materially reduced by careful and correct handling and planting.

TREATMENT OF OLD TIMBER

"Should the old stems and logs be burned or left to rot on the ground?" This was the subject of the next discussion.

Mr. Whitelaw said that by burning the timber the land was well cleared and this allowed drains, roads, lining and holing to be done without interruption, but, on the other hand, if it was allowed to rot on the surface in two or three years' time it would provide valuable food for the young trees. There was doubt whether by leaving the logs to rot there was a danger of increasing the incidence of Fomes.

Mr. Murray said that in his opinion the existence of rotting wood above ground was not a factor of importance in the subsequent incidence of root disease. The wood was so rapidly invaded by saprophytic wood-destroying fungi and insects that there was little likelihood of spores of disease organisms, *e.g.*, *Fomes lignosus*, gaining a hold. He agreed with Mr. Whitelaw that the decaying timber would restore organic matter and plant nutrients to the soil which would otherwise be largely or entirely lost.

In reply to an enquiry regarding the breeding of the Coconut beetle in decaying Rubber logs, Mr. W. C. Lester-Smith (Controller of Plant Pests) said that this was certainly a breeding place for such insects. The practice of leaving the timber to decay would be a serious source of danger to neighbouring Coconut estates. For ease of administration the Coconut beetle had been declared a pest throughout the Island, but preventive measures would only be enforced in Coconut districts.

In reply to an enquiry Mr. Keiller said that he did not think there was much potash value in the ashes of burned Rubber wood.

DENSITY OF PLANTING

Mr. Whitelaw said there were very wide variations in advice being given as to correct stand per acre. He pointed out that some clones, such as P.B. 25 with upright crowns would stand closer planting than the clones of wide spreading habit such as Tj. 1 and A.V. 152. He did not think that when Tj. 1 was fully mature there would be room for more than 90 to 100 per acre. He could not understand why some authorities advocated stands of 200 to the acre. Such dense planting might give high yields when tapped over the first panel, but subsequent bark renewal would certainly be of the poorest.

Mr. May thought that in the case of some clones 90 trees per acre would be a suitable final stand. He advocated starting to thin out in about the third year and using the surplus plants

as stumped buddings for later clearings. The propriety of this was questioned by several speakers who thought that these would mostly be the poorer plants and should, therefore, not be used.

Mr. I. L. Cameron preferred to aim at a final stand of 120 per acre on the grounds that replanting would probably be undertaken at intervals not exceedingly 25 to 30 years.

TREATMENT OF GRASS

Mr. Whitelaw's next topic for discussion was treatment of grass. He favoured the total eradication of all grasses from the commencement, and said that grass was universally condemned in old Rubber, so he could not understand why some planters were willing to let it grow in young Rubber. He considered the removal of the grass as the first step to the establishment of a good cover of legumes. The same view was expressed by Mr. J. C. Mitchell who said that grass should not be tolerated in either old or young Rubber.

Mr. Murray suggested that it was not always advisable to remove grass in one operation as this might expose the soil to serious loss by erosion. It was usually possible to replace it in stages by a creeping leguminous cover.

TYPE OF COVER

The respective merits of upright and creeping covers were next discussed.

Mr. Whitelaw expressed a strong preference for Pueraria. saying that although the early growth of the young Rubber plants might be checked by root competition the trees would eventually benefit from the heavy litter of decaying leaves. On his own estate he had brought a replanted clearing into tapping in six years under Pueraria, and the soil now contained an abundance of earth-worms where none were before. His main objection to uprights was that they generally seemed to die off in 2 years, leaving the land in heavy grass.

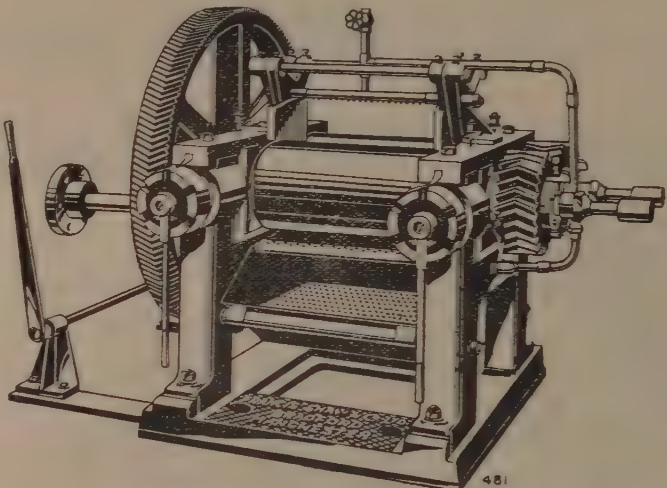
Mr. Murray confirmed Mr. Whitelaw's statement that in the experimental plots at Dartonfield, although the growth of budded Rubber under Pueraria was the most backward in the first 3 years, recent measurements showed that the rate of increase in the fourth year was best in the Pueraria plots.

Mr. Whitelaw considered that this confirmed his views that when the Rubber roots leave the holes and reach the ordinary surface they find that the best reconditioned soil is that which has been under Pueraria.

Mr. Bruce Foote said that in one case where his Pueraria had been uncontrolled the growth had been very backward, but in another clearing the cover had been properly controlled, and the growth was excellent.

Another member asked whether a heavy growth of Pueraria could be the cause of so many of his buds lying dormant. Both Mr. Murray and Mr. Whitelaw were of the opinion that Pueraria could not be the cause of buds remaining dormant.

Various opinions were expressed, and it was agreed that if a vigorous ground cover like Pueraria was used adequate control in the early years was the keynote of success.



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